The University of Chicago

# THE GEOGRAPHY OF SOUTH DAKOTA

A DISSERTATION

SUBMITTED TO THE FACULTY
OF THE OGDEN GRADUATE SCHOOL OF SCIENCE
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

DEPARTMENT OF GEOGRAPHY

BY

STEPHEN SARGENT VISHER

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CHICAGO, ILLINOIS

Reprinted from
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# The Geography *of* South Dakota

A Detailed Discussion of the

SURFACE, RESOURCES, CLIMATE, PLANTS, ANIMALS, and HUMAN GEOGRAPHY

Including the HISTORY of the Area.

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*A Study in Regional Geography*

By

STEPHEN SARGENT VISHER, Ph. D. (U. of Chicago)
United States Geological Survey

## PREFACE

The following study is based on extensive field work and nearly all the available literature on the subject. The regular field work, done under the auspices of the State Survey, when Ellwood C. Perisho was State Geologist, occupied most or all of four seasons and involved reconnaissance work in more than three-fourths of the counties of the state and detailed work in several, (see the Geography, Geology, and Biology of South-Central South Dakota and the Biology and Bio-geography of North-Western South Dakota, Bulls. V and VI of the State Survey.) A residence in the state, extending over most of my life and including three years (1910-1913) as an instructor in the University of South Dakota, has greatly increased my knowledge of local conditions. Assistance in the field investigations was received from Dr. Perisho, then State Geologist, W. H. Over, Naturalist of the Survey, B. A. Iverson and Ralph W. Chaney, members of Survey field parties. Of the long list of publications dealing with the state from which facts have been obtained, special mention should be made of those of the first State Geologist, J. E. Todd. While writing the manuscript, many valuable suggestions were received from professors at the University of Chicago: Dean R. D. Salisbury, especially on chapters I-IV, VI; Dr. W. S. Tower on chapters I, V, VII; Drs. H. C. Cowles and Professor J. Paul Goode on chapters VI and VII; V. E. Shelford, on chapter VI; and Professor H. H. Barrows on chapter VII; and also my wife. Few changes have been made in the manuscript since February 1915.

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# The Geography of South Dakota

## CHAPTER ONE

### INTRODUCTORY

Location, p. 7; Shape, p. 8; Area, p. 9; Boundaries and their selection, p. 9.

### GEOGRAPHIC LOCATION AND ITS SIGNIFICANCE

South Dakota is nearly equally distant, about 1300 miles, from the Atlantic and Pacific oceans, having approximately the same longitude as North Dakota, Nebraska, Kansas, Texas, and central Mexico, and in mid-latitudes, having, approximately the same latitude as Oregon, Wisconsin, southern Ontario, New Hampshire, northern Italy, and south-central Manchuria. The forty-third parallel forms most of the southern boundary of the state; the northern boundary is near the forty-sixth. The geographic center of North America probably is within the state. The eastern part of the state is in the Prairie Plains, most of the remainder in the Great Plains; an outpost of the Rocky Mountains (the Black Hills) occupies much of the southwestern quarter.

The location of an area is of very great geographic importance. All large areas differently located differ in regard to climate, geology and mineral resources, topography, political and industrial relations, and the stage of the development of the area.

The location in the northern Great Plains and Prairie Plains of the United States determines (1) the general type of climate (marked seasonal changes, uncertain rainfall,) (2) the general plan of the topography (the Great Plains section is a gentle piedmont slope, the Prairie Plains section has been glaciated), (3) that over wide areas the rock strata are nearly horizontal but that in the region of the Black Hills the strata are disturbed and ores are found, (4) that the population is English-speaking, chiefly Teutonic, and progressive, (5) that the area long was on or beyond the frontier and still is so in respect to manufacturing, and (6) that the major activities of the population are grain growing and grazing, results of the factors just enumerated.

#### South Dakota as a Frontier Area

Although the southeastern corner of the state was settled in the '50's and '60's, and most of the eastern third by the end of the '80's, much of the free land of the western half was not appropriated until after 1905. The experience and opinions of the pioneer "homesteaders," many of whom were poorly prepared for the hardships encountered and who in many cases were but temporay sojourners in the state, have influenced greatly its reputation.

The states lying east of the longitude of Dakota, because of greater and more reliable rainfall and closer proximity to markets, have a relatively dense population, with better developed industries and larger cities. Directly west of South Dakota, there has been no great development until quite recently. The chief development was for a long time to the north (Washington) or south (California) of the latitude of this state, which is a partial explanation of the fact that although North Dakota and Nebraska had transcontinental railroads by 1890, the first

one across South Dakota was completed in 1909. The major cause of this lack is, however, the character of the Rocky Mountain barrier. The Black Hills intercept the southern half of the state, while west of the northern half there are no easy passes across the main chain.

The development of adjacent and neighboring states to the north and south has been similar to that of South Dakota, their trade and travel using east-west routes. Consequently there has been no great demand for north-south railroad transportation across these states and until quite recently most of South Dakota was relatively inaccessible by rail from either North Dakota or Nebraska. The Black Hills formerly were more closely associated commercially with Nebraska than with eastern South Dakota, because until 1907 the only railroads into these Hills were from the south.

Only since the building of the Puget Sound extension of the Chicago, Milwaukee & St. Paul Railroad (1907-09) has territory outside of South Dakota been commercially tributary to that state, as parts of southwestern North Dakota now are.

The commercial outlet of South Dakota has been towards the east. The grain exported has reached its chief market, the eastern states and northern Europe, by way of Chicago or more recently by way of the Great Lakes from Duluth to Buffalo and beyond. With the great development of the flour mills at Minneapolis and the increase of lake transportation which followed the deepening of shallow parts of the channel, notably the construction of larger locks at Sault St. Marie, the latter route has gained in importance. The live stock went chiefly to the great slaughtering houses at Chicago until the passage of the 26 hour law gave Sioux City an advantage.[1] Sioux Falls became an important pork packing center in 1911.

South Dakota has no great advantages for wheat and cattle raising over several other areas likewise chiefly engaged in growing these products, and therefore has developed no faster than they, and still has a relatively small population (about 650,000.)

Its location affords the state some slight advantages over its northern, western, and southern neighbors. The corn belt, as that term is used by the Federal Department of Agriculture, extends a considerable distance into South Dakota, but not into North Dakota. The temperature is somewhat lower than in Nebraska, and in this respect, in sections of the two states having similar precipitation, conditions are more favorable for vegetation in the northern state. Hail and tornadoes are less frequent than farther south, and blizzards rarer than in North Dakota. South Dakota has more rainfall and is nearer to the great eastern markets than are Wyoming and Montana.

### Shape

In shape South Dakota is a rectangle imperfect because of Lakes Traverse and Big-Stone which indent the northeastern corner, and the river boundaries of the southeastern corner.

The average length (east-west) of South Dakota is 370 miles (extreme length, 380 miles), and the average width (north-south) about 200 miles (extreme width, 238 miles.) The shortest distance between New York City and Washington D. C., and between Copenhagen and Berlin is, in each case, about 200 miles; between Berlin and Stockholm about 370 miles, and between Buffalo and Boston about 400 miles. These figures give some idea of the area of the state.

The rectangular shape of South Dakota, with the greatest dimension east-west, is in part the result of the commercial relations of the state.

[1] A Federal statute which requires that live stock en route to market must be fed and watered at intervals not exceeding 26 hours.

Since the chief markets are to the east, the chief lines of communication run east-west and tend to unite communities along them. Nothing unites communities north or south of such lines so closely. The lesser width is approximately equal in hours of railroad travel to the greater length. Except on a single line (Yankton to Aberdeen) it requires about as long to cross the state from north to south as it does from east to west or in some places even longer. Chicago can be reached from many stations in eastern South Dakota in less time than it takes to reach many stations less than half as far away to the north or south.

The state extends just far enough westward to include the important mining part of the Black Hills. This mountain mass introduces diverse elements in topography, climate, vegetation, rock formations and industry, and is chiefly responsible for the greater diversity found in South Dakota than in the neighboring states of North Dakota, Iowa and Nebraska which have no mountainous area. Different points of view have been developed among the people engaged in mining, grazing on the plains, large scale agriculture in parts of the northeastern quarter, and mixed farming. This diversity is a factor of economic and social strength, but it complicates legislative problems, since representatives from diverse sections and occupations are in many cases unable to appreciate the general needs.

### Area

The area of the state is 77,615 square miles or about fifty million acres, of which 747 square miles are covered permanenttly by rivers and lakes. This 747 square miles of submerged land is in contrast with 3,824 square miles for Minnesota and 4,447 for New England. The state has approximately the same area as Nebraska, Kansas, or Minnesota, or as New England with New Jersey and Delaware added. South Dakota is 50 per cent larger than the combined areas of the Netherlands, Belgium, Denmark, and Switzerland, and is almost as large as Great Britian (England, Scotland, and Wales.)

From these comparisons some suggestion as to the possible significance of the area of South Dakota may be obtained. Of course its location and resources are not at all on a par with those of Great Britian, for example, but it seems evident that in the distant future, when the resources of the state are completely utilized, it may support well a population several times as great as it now possesses.

### Boundaries

Geographic factors influenced the establishment of at least the northern, eastern, and southern boundaries.

In territorial days (before 1889) the chief factor in regard to the determination of the boundaries was perhaps the location of this area near or beyond the western limit of compact settlement. The Missouri River, conspicuous and well-known, long served as a boundary of territories. The following enumeration of territorial boundary changes in many cases is suggestive of geographic influences in the locations of boundaries.

Between 1803 and 1812 Dakota was part of the Louisiana Territory. Between 1812 and 1861 the section west of the Missouri River was included in Nebraska Territory. The section east of the Missouri belonged, successively, to the territory of Missouri (1812-1834), Michigan (1824-1836), Wisconsin (1836-1838), Iowa (1838-1849) and Minnesota (1849-1858). From 1858 to 1861 it was unorganized, and known as the "Land of the Dacotahs." Dakota Territory, as organized in 1861, included what now are North and South Dakota, most of Montana, and parts of Nebraska and Wyoming In 1863 it was reduced to approximately what is now North and South Dakota. In 1864 it was again

extended, but a permanent reduction was made in 1868. Minor changes along the Nebraska-South Dakota boundary were made in 1870 and 1882.[2]

**The Eastern Boundary.** The eastern boundary of Dakota Territory was the western boundary of Iowa and Minnesota, in other words, the Red River, Lake Traverse and Bigstone, the meridian south from the end of the latter lake to Iowa and the Big Sioux River to its junction with the Missouri.

The Red River of the North nearly follows a meridian for a long distance. The fact that its source is in Lake Traverse increases its significance as a natural boundary since Lakes Traverse and Bigstone are the longest lakes for many miles, and were of importance as sites of Indian settlements with which there was fur trading before 1750. A short distance south of the end of Lake Bigstone, the Big Sioux River, also an important stream in the early fur trade, having been visited by the French before 1700,[3] comes to approximately the same meridian and continues south near it to the Missouri River, which stream in turn flows southward into the state of Missouri. This combination of waterways forms a rather striking geographic boundary line.

As the area between this dividing line and Wisconsin and Illinois was sufficiently large to permit the creation of two average sized states between Missouri and Canada, it was rational that this strongly suggested north-south line should have been adopted as the western boundary of Iowa and Minnesota. The absence of a geographically suggested boundary either to the east or west of this one and still sufficiently near to it so that the territory to the east as far as the Mississippi would give averaged-sized states,[4] increased the likelihood of the choice of this line.

In the adoption of boundaries for states, Congress was influenced greatly by the boundaries as well as the areas of older states. In several cases the same or approximately the same meridians or parallels are used as parts of the boundaries of three or more states, and other parts of streams which formed the boundary for parts of older states in many cases were taken advantage of in bounding younger states.

Iowa, as admitted in 1845, had for its western boundary approximately the meridian which formed much of the western boundary of Missouri; but in 1846 it was extended westward to the Missouri and the Big Sioux rivers. The rather sharp western bend of the Missouri near the mouth of the Sioux doubtless was a factor, in addition to that of the area, favoring the choice of the lesser stream as a boundary.[5]

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[2]Gannett, H.: The Boundaries of the United States and the several states and territories, Bull. 226, U. S. Geol. Sur., pp. 117-132, especially p. 129, Washington, 1914.

[3]Robinson, Doane: A Brief History of South Dakota, p. 22, (New York, 1905).

[4]Had the relatively insignificant Dakota River, but slightly known in 1846, when the present western boundary of Iowa was established, been chosen, the area to the north of Iowa would have been more than 115,000 square miles, about 35,000 square miles larger than Minnesota, and greater than any states then admitted except Texas. In 1846 there was great objection in Congress to the making of states of large size.

[5]The boundaries of Iowa, as provided by Congress in 1845, gave it an area much smaller than its present one. The reason for this small size was the desire on the part of a majority in Congress to carve many, rather than few, states out of the free territory. The people of Iowa so strenuously objected to this restricted area that they twice rejected the constitution offering admission with these boundaries. They demanded, instead, the so-called "Lucas boundaries", by which the Missouri River formed the western boundary and the northern boundary extended northeast from the mouth of the Sioux River, including in Iowa several counties now in southeastern Minnesota. The basis for these demands were, (a) the desire for a larger area, and (b) the desire for the "natural" boundary afforded by the Missouri River. The present boundary was a compromise offered by Congress in 1846. The parallel of 43° 30′ was followed from the Mississippi River to the Sioux River. Thus

When Minnesota was about to be admitted in 1858, the choice of its western boundary probably was influenced by the fact that the meridian followed approximately by the Red River and Lake Traverse was approximately the one roughly followed by the rivers which form the western boundary of Iowa and part of Minnesota.[6]

**The Western Boundary.** The western boundary is the meridian 27° west of Washington, D. C. (approximately 104° west of Greenwich.) It is not known that geographic factors directly determined the selection of this particular meridian. The fact that it passed through the mouth of the Yellowstone River, near which point was located the then important Fort Union, suggests that they did, but search in U. S. House and Senate Documents, the Congressional Globe, and elsewhere has failed to reveal the cause for the choice of this meridian. During 1863 and 1864 it served as the western boundary of all the Dakota Territory. During the latter year the Territory was extended greatly westward south of the 45th parallel. In 1868, when Wyoming Territory was formed, this meridian again became the sole western boundary. In 1867 the western boundary of northern Nebraska was established on this meridian, so in adopting it, Nebraska followed Dakota.

**The Southern Boundary.** The southern boundary of Dakota Territory was established in 1861 when the Territory of Nebraska was divided. The 43rd parallel was followed to the Keya Paha River, which was followed to the Niobrara River, which in turn was followed to its junction with the Missouri, which formed the rest of the boundary. In 1882, the unsatisfactory nature of a boundary determined by small, crooked streams was realized, and the 43rd parallel was made the boundary eastward to the Missouri River. In 1870 a minor adjustment, made desirable by the shifting of the main channel of the Missouri, was made, and a small area was ceded to Nebraska.

It may be conjectured[7] that the choice of the 43d parallel was made (1) because it approximately extends the line of the big eastward bend of the Missouri River, (2) it nearly follows the divide between the White and Niobrara River, (3) it is just south of the southern border of the Black Hills.

**The Northern Boundary.** The Territory of Dakota extended northward to the Dominion of Canada. It was divided in 1889, into two states, along the seventh standard land survey parallel and a westward extension of this parallel. This line is four miles south of 46° north latitude. Its choice made the division of townships unnecessary, a division which would have been necessary had the 46° parallel

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the area demanded by Iowans was reduced in the northeast but extended by about one-third the amount of this reduction in the northwest. (Shambaugh, B. F.: "The History of the Constitutions of Iowa", pp. 256-284, 206-317, and his "Maps showing the Boundary History of Iowa", Ia. Jour. of Hist. and Politics, Vol. 2, p. 374, 1904.)

[6]The enabling act of Dec., 1856, gave the west boundary as the Red River, Lake Traverse and the Sioux River. The committee on territories, influenced, it is said, by the land speculators who had laid out Sioux Falls [Andreas Hist. Atlas of Dakota, p. 95, Chicago, 1884], substituted Lake Big Stone and the meridian due south from its southern end to the Iowa boundary for the Sioux River, which was considered by the chairman to be too small in its upper section and too crooked for a state boundary. This substitution deprived Minnesota of some 600 square miles, including the territory upon which Watertown, Brookings, and Sioux Falls are now located. (Winchell, Alex N.: "Minnesota's Eastern, Southern, and Western Boundaries," Minnesota Hist. Soc. Coll., Vol. X, pt. 11, pp. 677-687; and the "Congressional Globe" for Jan. 31-Feb. 25, 1857.)

[7]Search in government documents, publications dealing with Nebraska or Dakota and elsewhere has failed to disclose any discussion of the reasons for the selection of this precise boundary. The choice was made by the committee on territories, whose deliberations were not recorded. The chairman of the committee had travelled extensively through the west and in his speeches in Congress repeatedly showed an appreciation of geographic factors.

been followed. It also divided the territory approximately into halves.

Geographic influences which worked for the division of Dakota were (1) its large area—approximately twice the average size of the American states of today and nearly three times the average size of those which had been admitted already. North and South Dakota combined would have an area nearly three times that of the present medium sized states, such as Illinois, Iowa, and Wisconsin. (2) The community of interest between the more densely settled sections was very weak, because of the lack of communication. The lower (northern) portion of the Red River Valley was the first part of northern Dakota to be settled, while it was the extreme southeastern corner of southern Dakota which was first settled. Between these settlements was a tract nearly 400 miles in width, long sparsely settled, and crossed by neither navigable streams nor, until after 1887, by a railroad. With the coming of railroads, many lines which enter North Dakota came from Minneapolis—St. Paul, already a fairly important industrial center, while two of the more important lines which enter South Dakota came through Sioux City which is nearly due west from Chicago, a great railroad center. The chief railroad systems in South Dakota are the Chicago, Milwaukee & St. Paul, the Chicago and Northwestern, and the Chicago, Burlington & Quincy, while in North Dakota the chief ones are the Northern Pacific, the Great Northern, and the Sault St. Marie. Each of these lines has little or no mileage in the other state. Even today, as already remarked, the railroad communication between the two states is poor. (3) Many of the people predicted that what were then the more densely populated regions would remain widely separated by sparsely settled stretches. (4) A non-geographic factor was the selfish ambition of many office seekers. Two states meant twice as many state offices.

.The geographic factors of large area, lack of communication and widely separated settled areas, were appreciated and made much of by most advocates of division, in constitutional conventions, in instructions to delegates, and in memorials to Congress.[8] The agitation for division and statehood is treated more fully in Chapter 7, (p. 155.)

[8]Robinson, Doane: Papers relating to the Division of Dakota, S. D. Hist. Coll., Vol. IV, p. 56, 1908.

# CHAPTER TWO

## GEOLOGY.[1]

.The geologic formations have influenced (a) the topography and drainage, (b) the soil, and (c) the character and distribution of the mineral resources.

Most of South Dakota is underlain by nearly horizontal strata of poorly consolidated, and in most cases, relatively recent geologic formations. The accompanying geologic map[2] (Fig. 1) shows the general dis-

Fig. 1. Geological Map

1. Granite, Quartzite, Schists
2. Sandstone, Shale, Limestone
3. "Redbeds," Sandstone, Shale, Chalk,
4. Shale
5. Sandstone, Shale, Lignite
6. Clays, Marls, Sands.

tribution of the principal formations. It is evident from the map that, geologically, the state is an irregular basin with older formations outcropping at the east and west. The Black Hills form the most striking geologic feature. In these hills, formations representing nearly all periods up to the Tertiary outcrop in concentric rings around a core of very ancient schist and granite.[3]

In the southeastern quarter of the state (Sioux Falls to Mitchell) old quartzite outcrops at various points. Around it are Cretaceous for-

[1]The general references to the literature on the geology of the state are: Darton, N. H.: Geology and Water Resources of South Dakota, Water Supply Paper 227, U. S. Geol. Survey, 1909. Darton, N. H.: The Geology and Water Resources of the Great Plains, Prof. Paper 32, U. S. Geol. Survey, 1905. Todd, J. E.: A Preliminary Sketch of the Geology of South Dakota, Bull. No. 1, S. D. Geol. Survey, 1894. Todd, J. E.: The Hydrographic History of South Dakota, Vol. XIII. Geol. Soc. Am., pp. 27-40. 1901.

[2]Based on Darton's in Water Supply Paper No. 227.

[3]N. H. Darton's reports on the Geology and Water Resources of the Black Hills are authorities. The southern half is treated in Part IV of the 21st Annual Report of the U. S. Geol. Survey, 1901, and the northern part in Prof. Paper 65, 1909. Several Geologic folios, (Nos. 85, 107, 108, 127, 128, 164, treating of most of the Black Hills have been issued. 1902-1909.)

mations.[4] In the northeastern corner of the state, Pre-Cambrian granite is surrounded by shale and chalk of Creteceous age. The youngest extensive formation aside from the glacial drift of the eastern half of the state, is in the region between the Black Hills and the Missouri River, and is of Late Tertiary age.

(a) The relationship between the geologic formations and the topography and drainage is very intimate in the Black Hills region. The Hog-back-rim (a cuesta) due to the outcropping of resistant sandstone (Dakota and other formations); the Red Valley within the Cuesta, on the outcrop of softer shales (Spearfish red-beds); the Limestone Plateau, surrounding the core of the Hills, cut by superb canyons; and the "parks" on the crystaline rocks of the central mass are the larger features showing this relationship.

The buttes of the plains owe their existence in part to more resistant lenses of rock. Striking illustrations are the "tepee buttes," due in certain places (in the Pierre shales) to lenses of fossil shells, and in others (in the Fort Union formation) to lenses of chert. Bad-land topography appears to be developed best on certain Tertiary formations; at any rate it is associated with irregularly consolidated clays, marls and sand.

There are numerous illustrations of the adjustment of drainage to structure, and to formations of unequal resistance.

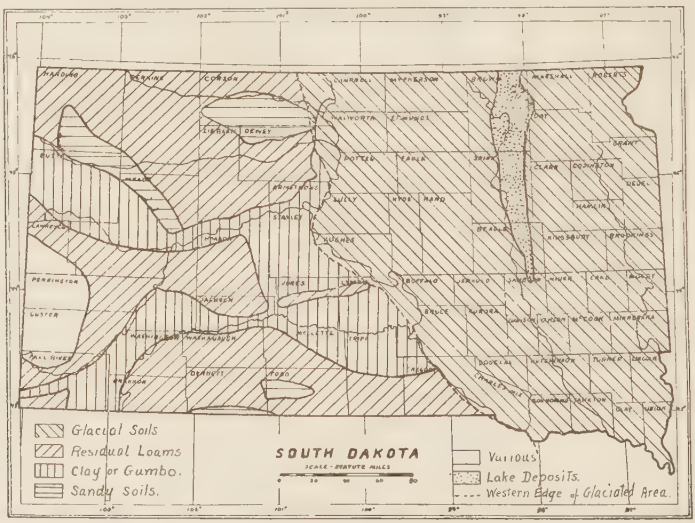


Fig. 2. A Generalized Soil Map

(b) A comparison of the soil map of the state (Fig. 2) with the geologic map shows a noticeable correspondence in the distribution of certain soil types and geologic formations. In the field the several geologic formations in many places may be recognized by the soils to which they give rise, even when the rocks are not expo ed. The soils vary strikingly in color as well as in texture and in tendency to crack. Conversely, knowing the underlying formation in any given region, a

[4]U. S. Geol. Surv., Parker, Alexandria and Mitchell Folios.
[5]Todd, J. E.: Hydrographic History of South Dakota, Bull. Geol. Soc. Am., Vol. XIII, 1901, pp. 27-40.

reasonable prediction can be made as to the nature of the soil. Five striking cases of correspondence between soils and geologic formations are (1) the gumbo derived from the Pierre shale, (2) the red sandy-loam developed from the Spearfish red-beds, (3) the light colored silt-loam from the White River formation, (4) the sandy soil of the dunes associated with the Rosebud formation, and (5) the clay-loam developed from the glacial drift. The eastern half of the state has a rather uniform type of soil because of the glaciation of that section. The glaciers rather thoroughly mixed the ingredients derived from the underlying rocks. The drift contains in most places so little stratified material that most of the drift can be classed as till.

The character and distribution of the mineral resources are determined in general by the rock formations, as will be pointed out in the next chapter.

# CHAPTER THREE

## MINERAL RESOURCES

Waters, p. 16; Clays and Cements, p. 21; Building Stones and Road Materials, p. 22; Mineral Fuels, p. 24; Ores in the Black Hills, p. 24; Miscellaneous Mineral Products, p. 26; Soils, p. 26.

The mineral resources of the states are varied.[1] The Black Hills are especially rich in ores and have yielded to date about 200 million dollars' worth of gold. For many years South Dakota ranked third among the states in the production of this metal, but recently it has taken fourth place. South Dakota leads the states in the production of lithia, and ranks third in the production of mica. There is a great variety of structural materials, most of which are present in large quantities, and there are somewhat extensive lignite deposits in the northwestern quarter of the state. In much of the state flowing wells may be secured at no great depth and have been of enormous value.

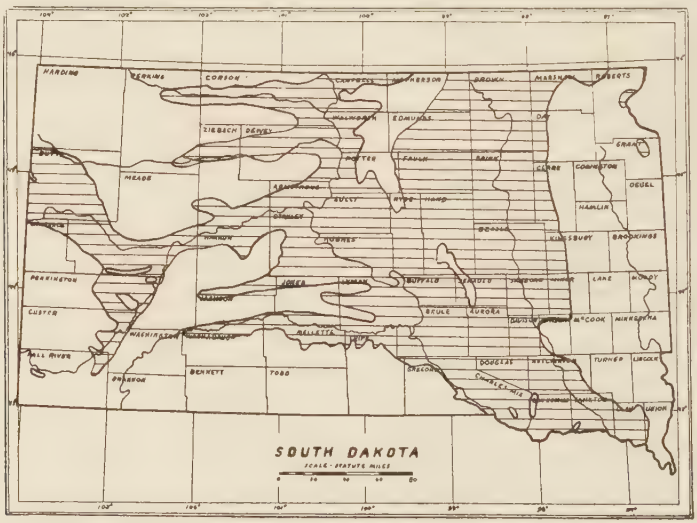


Fig. 3. Map indicating the approximate area in which artesian flows may be obtained. Non-flowing artesian wells may be secured in all areas except parts of the Black Hills and the eastern border of the state.

### I. Artesian and Other Waters

**1. Artesian Wells.**[2] Artesian wells are deep wells in which the water rises notably, in many cases flowing out of the well. In about half the area of the state (Fig. 3) a bountiful supply of pure water can be ob-

[1]The more important literature dealing with this topic was found to be two papers in Bull. 3, S. D. Geol. Survey, 1902, O'Harra, C. C.: The Mineral wealth of the Black Hills, and, Todd, J .E : Mineral, Building Materials, Fuels and Waters of S. D. The several Geologic folios, numerous volumes of the Mineral Resources of the U. S. issued annually by the U. S. Geol. Survey and the other bulletins of the U. S. and S. D. Geological Surveys and "The Mineral Industry" (annual) also afford some data.

[2]The chief references to literature upon the artesian wells in S. Dak. are: Darton, N. H.: The Geology and Underground Waters of S. Dak., Water Supply Paper 227, U. S. Geol. Survey, 1909. This summarizes and revises data given in the following less general reports: Darton, N. H.: Preliminary Report on

tained at little expense. In many cases the first cost of the well is the only cost for many years, there being no expense for pumping in the case of flowing wells.

At this time (1918) there are more than 5000[3] wells flowing constantly, and of this vast quantity of pure water only a small portion is used. The waste would not matter if the supply of water were inexhaustible, but we are far from sure that it is. Already many wells yield less than formerly, and the flow from some has stopped entirely. Probably in many cases this is due to the wells becoming clogged, or to faulty construction; but in many cases it seems to be due to the local depletion by the many wells of the water supply stored up through the ages in the porous strata beneath the surface.

Most artesian water has moved for great distances, in some places hundreds of miles, under ground. Much of this movement is by slow percolation during which the water has become germ-free. In most cases the water enters the porous, sandy "water-bearing" layer in some region where the layer is near the surface, and flows down under a more or less impervious layer.

In the artesian district, flowing or "tubular" wells are obtained from four different horizons, ranging from 60 to more than 3000 feet in depth. The shallower wells (60 to 200 feet) are from sands which in a number of localities are found at the base of the glacial drift or "bowlder clay." Flowing wells from this horizon are common in the Dakota River flood-plain, near Artesian in Sanborn county, and at a number of other points. Most of the shallower (100 to 400 feet) artesian wells are from a layer of sandstone in the Benton shale, which underlies the drift or both drift and chalk, where chalk is present.

The great source of flowing wells is the Dakota sandstone, from which nearly all the great flows come. This stratum in places is somewhat more than a hundred feet thick, and is filled with water. It comes to the surface as a ridge around the Black Hills and elsewhere along the foothills of the Rocky Mountains, several hundred miles from most of the wells and many hundred feet higher. Pressures as great as 250 pounds to the square inch[4] have been recorded at some of the wells. The largest well, at Aberdeen, flows 2,000 gallons a minute (more than 100,000 barrels per day), a quantity sufficient to supply the needs of a city with a population of 15,000.

The depth from the surface to the Dakota sandstone varies in different parts of the state, as well as with the relief of the surface. In the Dakota Valley its depth averages about 900 feet, ranging from 200 feet near Mitchell to 1,500 feet near Aberdeen. The only well east of the Missouri that is much deeper than 1,500 feet is that at Gettysburg (2,130 feet). West of the river there are several wells more than 2,000 feet in depth, and one at Edgemont, 3,000 feet. The latter penetrates a sandstone lower than the Dakota. Nearly all the cities and villages in the artesian area now secure their water supply from artesian wells.

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Artesian Waters of a Portion of the Dakotas. 17th Ann. Rept., U. S. Geol. Survey, Pt. II; Darton, N. H.: New Developments in Well-Boring and Irrigation in eastern S. D., 18th Ann. Rept., U. S. Geol. Survey; Darton, N. H.: The Bellefourche folio (No. 164), 1909; Todd, J. E.: The Aberdeen-Redfield folio No. 165, 1909; The Elk Point folio (No. 156), 1906; The Geology and Water Resources of portions of southeastern S. Dak., and of the lower James Valley, Water Supply Papers, No. 34 and No. 90, U. S. Geol. Survey, 1900, 1904. These two water supply papers incorporated many of the results secured while the making of the Parker and Olivet and the Alexandria, Mitchell, DeSmet and Huron folios.

[3]In Jan., 1912, Hon. Peter Norbeck, of the firm of Norbeck and Nickelson, the leading well-drilling firm in the state, and one which keeps a score of outfits at work, made this estimate.

[4]"Probably the greatest recorded artesian pressure in the world," (Johnson, Willis, E.: Dakota: A Republic of Friends, p. 43. (Pierre, 1911).

Most of the artesian waters have a temperature higher than the average temperature of the area for the year. In the Teton River Valley wells are distinctly warm, having temperatures of about 130° Fahr.

**The Uses of Artesian Wells.** It was not until the middle 1880's that successful attempts to secure wells on the uplands were made. For several years before there had been a few wells in the Missouri River flood-plain.[5] The first was completed at Fort Randall in what now is Gregory county, in 1881.[6] Until the late 90's the cost was beyond the means of most farmers.[7] Improvements of methods which greatly decreased the cost of construction, combined with good crops and a rapid rise in land values during the years following 1898, led to a great increase in the number of wells, a vast majority of which have been drilled since 1900. The present cost of artesian wells of ordinary diameters (2-3 inches) is about 50 cents per foot. The wells drilled in the 80's (with diameters of 5 to 9 inches) averaged more than $2.50 per foot.

The most important use of artesian water is for domestic and stock purposes. In many places pipes from the flowing wells furnish running water to buildings, gardens and lawns. In nearly all cases the water supply furnished is constant, convenient, abundant and wholesome, and in most cases is quite in contrast to that which was obtained before such wells were secured.

The most extensive use of water from artesian wells is for watering live stock. In most cases artesian water is preferred by stock because of its temperature, which is much warmer than air temperatures during the winter, and much cooler during the summer, and in many cases because of its appreciable mineral content.

The pressure of many wells is sufficient to throw a column of water to the top of the taller buildings of the region, and therefore such flowing wells may be an effective aid in ordinary fire-fighting.

The pressure has been used in a few scores of places for the production of power which has been used to run grinding mills, electric lighting plants and various sorts of machinery. The relatively low pressures (50-100 lb. per square inch) of most wells, the numerous cases of marked decline from the original pressure, and the competition of coal, gasoline and kerosene have discouraged the use of flowing wells for power.

Usually severe droughts occurred in the late 80's and early 90's and led to much speculation as to the practicability of using flowing wells for irrigation. Some very restricted areas, chiefly garden patches, were irrigated,[8] but artesian wells have been used to date to a very slight extent only for irrigation. Four factors appear to be responsible for this slight use: (1) In the artesian basin, periods during which irrigation is needed are often separated by months and years. Most farmers run the risk of an occasional short crop rather than prepare, and keep ready for use, an expensive irrigation plant with ditches which would interfere with the free use of the land in ordinary years. (2) Most of the flows are in the glaciated area where the topography is highly unfavorable for extensive irrigation. There are very few reservoir sites from which a large amount of water can be conducted by gravity on to an extensive gentle slope. (3) The water in most cases contains a good deal of mineral matter in solution and where large quantities of the water evaporate, the soil soon is loaded with salts and becomes unsuited to most sorts of vegetation. (4) The volume of water yielded by ordi-

[5]Yankton was supplied chiefly from Artesian wells in 1882, (Polks Gazetteer for Minnesota and Dakota for 1883, p. 1137, Detroit, 1882).

[6]The first artesian well in the western part of the state was dug at Bellefourche in 1892, (Tallent, A. D.: The Black Hills, St. Louis, 1899).

[7]There were about 100 wells distributed through 30 counties by 1889. The average cost was $5,000. (Hagerty: Terr. of Dak., p. 50, Aberdeen, 1889).

[8]Darton: 18th Ann. Rept. of the U. S. Geol. Survey.

nary flows is too small to be effective for the irrigation of considerable areas, unless it has been accumulated, as in reservoirs, for a long period. The high rate of evaporation results in a very slow rate of accumulation. Even voluminous flows in most cases are able to maintain a pond only a few acres in extent.

The presence of the artesian basin was not appreciated until after most of the area was settled, and consequently settlement was influenced slightly by it. However, land values have been greatly affected by artesian wells, as buyers accustomed to an unsatisfactory water supply readily pay much more for a farm upon which there is a flowing well than for another, even, in many cases, if the latter is located where an artesian well could be obtained at small cost. The lack of a suitable water supply has been a strong retarding factor in the settlement of many sections of the state.

Artesian wells have contributed to the prosperity of the artesian basin in the several ways already discussed. The advantage which is most appreciated by the hard-headed farmers is the influence of the good water supply upon cattle. These thrive much better in pastures having a convenient and altogether satisfactory water supply, than in other pastures.

**2. Shallow Wells.** Shallow wells now are used but little in the area where artesian wells are obtained readily. The depth to a relatively permanent abundant supply of water varies greatly with the relief, the mantle rock and the topographic location, but for much of the state the depth is between 20 and 60 feet, averaging perhaps 40 feet. The water from most wells in the Pierre shale and that from many in the glacial clay, has an alkaline taste and in some places is not palatable. Because of the relatively impervious nature of bowlder clay or other clay, comparatively few "dug" wells in these materials, furnish sufficient water to be considered "inexhaustible" in the popular use of that word. Accompanying the wide fluctuations in precipitation, the water table rises and falls greatly. Its great amplitude is not appreciated by most farmers, and many wells go dry in periods of drought. At such times water for domestic use may be hauled long distances, even being brought in by train, and cattle may have to go far for perhaps an unsatisfactory drink. Most of the cities and villages not in the artesian basin or in the Black Hills secure their water from shallow wells. Sioux Falls, the largest city in the state, is so supplied.

**3. Springs.**[9] Springs are scarce in most parts of South Dakota. This is due largely to the relatively impervious clay which mantles much of the surface, particularly most of the glaciated section and that in which the Pierre and Benton shales outcrop (see geologic and soil maps, Figs. 1 and 2). Where porous strata should appear normally, on the sides of the valleys, the overlying clay is likely to have slipped down so as to cover their outcrops, and seal up the water they contain.

The light rainfall prevalent over most of the state is another factor not conducive to springs.

In the Black Hills, as in most mountainous areas, springs are numerous. There are very large ones at the base of the compact purple limestone where it outcrops near Tilford and Hot Springs. Other large springs flow from the gravels along valleys.

In the sandhill districts, notably those in Shannon, Bennett, and Todd counties, there are many surprisingly copious springs along the valleys.

A few large springs along the lower course of the Missouri and Dakota rivers receive their water from the artesian basin. This is be-

[9] There are brief discussions of springs in each of the bulletins of the S. D. Geol. Survey: Bull. 1, p. 61; Bull. 2, pp. 40, 46-47, 109-110; Bull. 3, pp. 123-124; Bull. 4, pp. 68-69; Bull. 5, pp. 59-60.

cause the Dakota Sandstone, the chief water bearing formation, outcrops in the vicinity.

Several flattish-topped buttes in the western part of the state have relatively porous horizontal layers near their tops, and relatively impervious layers of rock lower down. At the contact of such layers there are numerous springs in each of the forested buttes in Harding County, and in many buttes in the bad-lands, and along the escarpments towards the southern border of the state. In the lignite area of the state there are many small springs whose water, in many cases, is dark-colored though rarely ill-tasting.

In Union and Lincoln counties many springs issue between the loess and the drift.

Gravel and sand deposits along some lines of drainage in the glacial period are now subterranean watercourses which yield springs. Wessington Springs in Jerauld county and several other springs in the glaciated area, especially west of the Missouri river, are of this origin.

**Springs and Human Geography.** In the glaciated area, springs have been used very little and have influenced settlement slightly. This is because nearly all of the relatively few springs are close to the few streams. The loess-covered area in Union and Lincoln counties is an exception. Here springs were used from the first and were determining factors in the location of many homes. Springs along the east side of the Wessington Hills determined the location of several homesteads, and copious mineral springs led to the location of the town of Wessington Springs.

Nearly all the towns and most of the homes in the Black Hills secure water for domestic purposes from springs, and springs were important factors in the location of numerous homes in that region.

The springs in the buttes are important in giving rise to permanent brooks. Near the mouths of nearly all of the larger valleys in the forested buttes in Harding County, ranch houses have long been located.

The springs in the sandhills have influenced settlement only indirectly. Ranch houses are located near spring-brooks. Water for domestic purposes is secured from shallow wells, which, in the sand, yield copiously.

Several Indian vilages in what was the Rosebud and Pine Ridge Reservations are, or were, located along the contact of the less porous White River beds and the Rosebud beds, which in many places are sandy. In the case of four of these villages, old Indians stated that the springs were the determining factor in their location.

There are several ranch heuses in valleys near the contact between the almost impervious Pierre Shale and the more porous overlying beds in several counties, notably Tripp, Gregory, and Fall River.

**4. Mineral Waters.**[10] The mineral waters of South Dakota are varied. The water of many wells and springs contains sufficient amounts of hydrogen sulphide or of carbonates and sulphates of iron, calcium, magnesium and sodium to be evident to the taste, but the only locality which has become prominent as a resort, largely on account of mineral water, is the Hot Springs region in the southern Black Hills. This locality long was known to the Indians as "Minnekahta," the name which has been applied by Darton to the limestone with which these springs are associated. There are several large hotels and baths in and near Hot Springs, and the large Federal Sanitarium and the State Soldiers' Home are located there. Mineral waters having an annual value[11] of somewhat more than $2,000 have been sold during recent years from springs near Hot Springs and one near Sioux Falls.

**5. Streams.** The streams are important sources of water for live

[10]Todd, J. E.: S. D. Geol. Surv., Bull. 1, pp. 114; Bull. 3, p. 121-129, (Vermilion 1894, 1902).

stock, especially where wells yielding an abundant supply are lacking. Streams have been used but sparingly for domestic purposes, in part because of their muddiness and their great fluctuation in volume. Almost the only streams which are fairly clear, except when ice-covered, are in the Black Hills, in the larger buttes, notably those of Harding County and the Big Bad Lands, or in the sand-hill areas. The minimum flow of each of the streams of the state, except the Missouri River, is small, and the only long streams which flow permanently throughout much of their courses are the Sioux, Dakota, Missouri, White, Teton, Cheyenne, Moreau and Grand rivers. The total length of these streams in the state is about 2,000 miles. Many streams which have their sources in the Black Hills and the sand-hills of Todd, Bennett and Shannon counties, though permanent near their sources, dry up farther down their valleys.

**6. Lakes and Ponds.** Lakes and ponds are fairly numerous in the extensive glaciated area where streams are few. They have had less value than the streams as sources of water, largely because of the fact that most of them are very shallow. In most cases this means muddy margins, high summer temperatures, and considerable aquatic life, while many of them disappear during the dry seasons. Furthermore, many are covered by ice for a longer period than are streams. Only the larger lakes are sufficiently cool and clear so that they are used extensively by stock which has a choice between lake and well water. Ponds and lakes have been used by man himself for domestic purposes but little, and this chiefly before settlement was well established. Considerable quantities of ice, however, have been cut on lakes, and upon pools in the smaller streams.

**7. Rainwater.** Cisterns have not been used as much as they should in South Dakota. This is due chiefly to the distribution of the rainfall. Most of the precipitation takes place in a relatively short period. In order to collect most of the rain which falls on roofs, cisterns have to be very much larger than in regions where the rainfall is distributed more evenly. During the long period when but little rain falls, there is in some cases loss of water by seepage, and a deterioration of the supply retained. Protracted droughts discourage reliance upon cisterns as a chief water supply.

Earthern dams have been built across numerous shallow valleys, especially in the western half of the state, and the reservoirs so created are a very important source of the water supply for a large part of the state. Numerous small towns secure water for domestic purposes from shallow wells sunk near such reservoirs.

## II. Clays and Cement Materials

**1. Clays** abound in the state but have been little utilized and have not been systematically studied.[12]. Although bricks have been manufactured in the past somewhat extensively at more than twenty towns,[13] including Vermillion, Yankton, Chamberlain, Pierre, Aberdeen, DeSmet, Madison, Englewood, Hill City, and Deadwood, they have been made in recent years only at Bigstone City and Rapid City, and many of the bricks made at the latter place are of the sand-lime variety. The value of the bricks produced during recent years has averaged somewhat less than $80,000 a year, of which nearly a third is accredited to sand-lime bricks. South Dakota has ranked forty-sixth in value of clay products among the states during several recent years. This low rank is not due

[11]U. S. Geol. Survey: Mineral Resources of the U. S., 1906-12

[12]S. D. Geol. Survey, Bull. 1, p. 158; Bull. 2, p. 132; Bull. 3, pp. 101-108; Bull. 4, pp. 55-56; Bull. 5, p. 60. The statistics of production are from "Mineral Resources of the U. S.", U. S. Geol. Survey, 1907-1912.

[13]There were 29 brickyards in Dakota in 1887, according to McClure: "Resources of Dakota," p. 278, (Aberdeen, 1887).

to scarcity of suitable clays, but chiefly to the expensiveness of fuel and to the small local market.

China clay, potters clay, and fire clay are found in the Black Hills region in considerable quantities, but only the last has been developed, and that but slightly.

Fullers' earth and volcanic ash appear in the badlands and eastern foothills of the Black Hills. The former has been shipped in small quantities from a point near Hermosa.

**2. Cement Materials.**[14] At various places, shale and chalky formations suitable for the production of Portland Cement are associated, and a score or more places might be found between Pierre and Yankton along the Missouri River, in the lower Dakota Valley and about the Black Hills, any one of which would be within easy reach of materials, fuel excepted, appropriate for the manufacture of cement. The chief production up to the present time has been at Yankton,[15] where in 1900 some 40,000 barrels of cement were manufactured. The plant was purchased and shut down in 1909 by the "trust," and there is now no production of cement in the state.

**3. Gypsum.** Extensive deposits of gypsum are interbedded with the Redbeds in the Red Valley which surrounds the Black Hills. They have been worked on a large scale near Sturgis, Rapid City, Hot Springs, and Alabaster. The gypsum is calcined, ground, and made chiefly into stucco (which will set in 8 to 10 minutes) or plaster of Paris (which sets in 45 to 50 minutes.) Dental plaster is made also. The production of gypsum has increased very rapidly during recent years, and it seems probable that it will long continue to increase. Precise figures of the production for South Dakota are not given in "The Mineral Resources of the United States" or in "The Mineral Industry."

4. **Limestone** of very pure quality is present in large quantities and in accessible locations at many places in the Black Hills. It has been burned for lime chiefly near Rapid City. The value of the product was $25,000 in 1910 and $37,500 in 1911. Formerly small quantities of chalk were burned and yielded a poor grade of lime in the lower Dakota Valley.

### III. Building Stones and Road Materials[16]

**(1) Granite.** Although vast quantities of granite are exposed in the Harney Peak district of the Black Hills, it has little value as a building stone because of its very coarse granular texture. Its distance from railroads and markets would make it now nearly worthless for building-stone even if the texture were the best. In the northeastern corner of the state, there is a fine-grained granite which recently has been quarried extensively for tombstone and decorative purposes. Most of the somewhat famous Ortonville granite now comes from South Dakota, instead of from Minnesota.

**(2) Porphyry.** Various kinds of eruptive rocks, popularly known as porphyries, are widely distributed in the northern Black Hills. Although little or no extensive quarrying has been done yet in these rocks, several varieties may be valuable in the future for ornamental purposes.

[14]References to the literature on Cement Materials: S. D. Geol. Survey, Bull. 1, pp. 156-157; Bull. 3, pp. 99-101; Bull. 4, p. 56; Bull. 5, p. 60; U. S. Geol. Survey: Mineral Resources of the U. S.: (Annual); and O'Harra, C. C.: The Cement Resources of the Black Hills, S. D., School of Mines Bull. 8, (Rapid City, 1908).

[15]The Yankton Portland Cement plant was claimed to be the largest of its kind in the U. S. in 1892, (Clough, Rev. E. E.) in Seneca Falls, N. Y. Courier for 1892).

[16]The literature on the Building Stones and Road Materials is scattered. The following are the more important: The folios of the U. S. Geol. Survey listed at the beginning of the previous chapter; Bull. 3, S. D. Geol. Survey, pp. 82-89, 1902. The figures on the production are based upon those reported in the annual Mineral Resources of the U. S. Geol. Survey, 1907-1912.

**(3) Quartzite.** Quartzites are present in several parts of the Black Hills, and equally hard cherty layers on buttes, notably on Cave Hills, but also on the Bijou Hills, east of the Missouri River. The only quartzite deposit which is developed commercially is that in the southeastern corner of the state. The rock here has a bright color, in most places some shade of red. It is more easily worked, and yields blocks of larger size than can be obtained from this sort of rock in most parts of the world. It has been extensively quarried at or near Sioux Falls, and Garretson. The foundations and lower walls of numerous buildings were built of quartzite before other satisfactory building stones, notably the Bedford limestone, could be obtained more cheaply. Of late years the quartzite has been quarried chiefly for crushing, for use on roads, and has been shipped extensively as far as Chicago.

**(4) Bowlders.** East of the Missouri River and a short distance west of it are many scattered glacial bowlders of granite, trap, quartzite, limestone, and other rocks. They are relatively few except in the moranic belts, but there they are found in such abundance that they will long supply the local demands for rough building stone.

Within a hundred miles of the Black Hills there are found, especially on the terraces of the streams which head in the Black Hills, many small bowlders and cobblestones. In the future they may be of some value.

**(5) Marble.** There is marble in two or three localities in the Black Hills, but it has been quarried only near Custer. The output to date has been small.

**(6) Limestones.** In the Black Hills there are several limestone formations, some of which are locally marble-like, which have been quarried for stone and for lime. There is an abundant and well distributed supply, and it is probable that the limestone of this section will have increasing importance. The value of the annual production during recent years appears to have ranged between $6,000 and $50,000. Precise figures for most years are not given in the Mineral Resources—South Dakota being grouped with other states whose production of limestone is low.

**Chalk.** Chalkstone, though it outcrops in the southwestern and northeastern corners of the state, has little economic significance, except along the Missouri between Yankton and Chamberlain, and along the lower tributaries of the Dakota. Formerly it was burned for lime and used as a building stone by the Mennonite colonies, and others of that region.

**(7) Sandstones.** Nearly inexhaustible supplies of choice sandstones are found in the Black Hills, and varieties suitable for rough building purposes are found in various other parts of the state, especially in the Cave Hills in Harding county. In the Black Hills the more important formations yielding high grade sandstone are associated closely in the hog-back rim of the Hills. Tests have shown that the Dakota sandstone in many places is one of the best building sandstones. The National Sanitarium and many other large buildings at Hot Springs and elsewhere are made of it. The value of the sandstone quarried in 1908-12 averaged about $130,000 a year.

**(8) Sand and Gravel.** In more than three-fourths of the state sand and gravel can be obtained only with great difficulty in sufficient quantities for local needs. In the areas where the Cretaceous clays (Fig. 1) outcrop, gravel and sand are almost lacking, and in the glaciated area they are present chiefly as small pockets of irregular distribution.

There are somewhat extensive sandy belts in Sanborn and Brown counties. Good sands and gravels are abundant in the Big Sioux valley.

Those in western Sanborn and Brown counties have been explained[17] as the result of the sorting by waves of glacial Lake Dakota, but the topographic relations in the former locality do not support this explanation, though no plausible one can be offered. Little of the sand of eastern South Dakota is sufficiently clean to be readily available for structural uses. Most of the sand and gravel used in the towns and cities of eastern South Dakota is transported by rail, much of it long distances. Relatively little of the railroad grades was ballasted until recent years, partly because of the scarcity of good local supplies of gravel. A short distance south of Mitchell and near Blunt deposits of gravel have been used for that purpose.

### IV. Mineral Fuels

(1) South Dakota is poor in mineral fuel as well as in fuels of other sorts. Although **bituminous coal** is present and is mined extensively on the western side of the Black Hills in Wyoming, it has not been found in workable quantities in South Dakota, though a little is known near Edgemont.

**(2) Lignite** is found in several parts of the state. Thin seams of it are struck frequently in the eastern part of the state in digging wells, but because of their thinness and the abundance of water, they are not workable. In the northwestern corner of the state, particularly in the northern parts of Harding and Perkins counties, there are large quantities of lignite of fair quality. Perhaps a hundred townships (3600 square miles) are underlaid by beds of some value. Seams three feet thick are not rare, and in a few places there are beds ten feet thick. The better grades of lignite make a good stove coal. More energy can be obtained from a ton of lignite burned in a producer gas engine, than from a ton of the best bituminous coal burned under an ordinary steam boiler; so it is not to be despised. Even as stove fuel, its presence has greatly facilitated the settlement of the northwestern portion of the state. Hundreds of "openings' have been made, and the local demand for fuel to a large extent satisfied. It is somewhat doubtful if the deposits ever will be commercially very important in South Dakota, as the seams in most places are thin and overlain by soft shale which makes a poor roof for mines. A somewhat detailed examination of the coal fields of South Dakota was recently completed by the U. S. Geoloigcal survey and the available tonnage of minable lignite given as 1,096,480,000.[18]

**(3) Natural Gas.**[19] Gas has been struck when drilling for wells in various parts of the state, and formations which may, in restricted areas, contain considerable supplies of gas or oil are widespread. The output has been small and unimportant, with the possible exception of the Pierre area, where for nearly 20 years a large portion of the lighting and cooking in Pierre and Fort Pierre was done by natural gas. It comes to the surface dissolved in the water of several artesian wells and is collected in tanks built over them. As a result of decrease in the output, and increase in the population, it is now of relatively little importance. In 1911 it was being used from 41 artesian wells, and had for that year an estimated value of $17,000.

### V. Ores in the Black Hills[20]

**(1) Gold.** Gold has been by far the most important of the metals

[17]Todd, J. E.: Mitchell and Aberdeen-Redfield (p. 13), Folios of the U. S. Geol. Survey. 1909.

[18]Lignite Field of N. W. South Dakota, U. S. G. S., Bull. 627, 1916.

[19]The only fairly satisfactory treatments of the natural gas are: Todd, J. E.: Bull. 3, pp. 114-119, 1902; Bull. 4, pp. 52-54, S. D. Geol. Survey, 1902, 1908.

[20]O'Harra, C. C.: The Mineral Wealth of the Black Hills, Bull. 6, S. D. School of Mines, and part of Bull. 3, S. D. Geol. Survey, 1902, is the general reference on the topics treated in this section. Recent productions is based on statistics given in the Mineral Resources of the U. S. U. S. Geol. Survey, 1907-1912, or in "The Mineral Industry." (Annual).

mined in the state. It has contributed more than 90 per cent of the value of the annual product of the mines and quarries and also was important in attracting settlers to the state. It was discovered near Custer by the Custer Expedition in 1874, and near Deadwood late in 1875. Permanent operations commenced in 1876, before the purchase (for $4,500,000) of the Black Hills region from the Indians in 1877. For several years operations were restricted to placer mining. Until 1885 the Black Hills had no railroad, and machinery had to be freighted long distances, in most cases from Bismark, N. D., Cheyenne, Wyo., or Sidney, Neb. This prevented the building in the Hills of complete plants for the treatment of ores, and such ore as required treatment out of the Hills had to bear the expense of very long haulage. The southern edge (Buffalo Gap) of the Hills was reached by the Chicago and Northwestern Railroad in 1885, and Deadwood was entered by the same road late in 1890 and by the Burlington early in 1891. Since 1890 the mining has been chiefly of low grade ores.

The gold bearing ores are found in considerable quantities in the (a) slates, schists and quartzites of Proterozoic age, (b) "cement" rocks or conglomerate of Cambrian age, (c) limestone of carboniferous age; and (d) recent unconsolidated deposits.

**Production of Gold in South Dakota since 1875, Mineral Resources, 1910, U. S. Geological Survey.**

| Year | Value | Year | Value | Year | Value |
|---|---|---|---|---|---|
| 1876 | $1,200,000 | 1888 | $2,600,000 | 1900 | $6,177,600 |
| 1877 | 2,000,000 | 1889 | 2,900,000 | 1901 | 6,479,500 |
| 1878 | 2,250,000 | 1890 | 3,200,000 | 1902 | 6,965,400 |
| 1879 | 2,500,000 | 1891 | 3,550,000 | 1903 | 6,826,700 |
| 1880 | 3,305,843 | 1892 | 3,700,000 | 1904 | 7,363,977 |
| 1881 | 4,000,000 | 1893 | 4,006,400 | 1905 | 6,989,492 |
| 1882 | 3,300,000 | 1894 | 3,868,155 | 1906 | 6,841,469 |
| 1883 | 3,200,000 | 1895 | 3,869,500 | 1907 | 4,188,189 |
| 1884 | 3,300,000 | 1896 | 4,969,800 | 1908 | 7,657,376 |
| 1885 | 3,200,000 | 1897 | 5,694,900 | 1909 | 6,577,836 |
| 1886 | 2,700,000 | 1898 | 5,699,700 | 1910 | 5,402,257 |
| 1887 | 2,400,000 | 1899 | 6,469,500 | | |
| | | | | Total | $155,303,594 |

In the southern Black Hills, the gold comes mainly from quartz veins; in the middle Hills chiefly from placer deposits, which are worked in the upper part of the Rapid Creek basin by means of dredges; and in the northern Hills chiefly from auriferous lodes ("leads"), slate breccias, fissure veins and, most important, impregnated zones. The Homestake mine is on such a zone of low grade ore. This one mine has produced more than all others, in spite of the fact that the ore worked has had an average value of only about $5.50 per ton. Its annual production since 1898[21] has averaged about $5,000,000.

(2) **Silver** is second in value among the metaliferous products of the state. The total production to date is approximately $4,000,000. It is found in small but fairly regular amounts associated with gold and lead, with the latter especially in the Galena, Carbonate and Spokane localities.

(3) **Lead** is distributed widely and is secured each year in small quantities, (13 tons in 1908, 7 tons in 1910, 33 tons in 1911.)

(4) **Copper** deposits which appear to be fairly rich are known at various places, especially in the northern Black Hills, but as yet the production has been small, (30,500 lbs. of metal in 1908, 42,000 lbs. in 1909, 23,657 in 1917.)

[21]The Homestake mills were put in operation July 1, 1878, (Tallent: The Black Hills, p. 510, St. Louis, 1899).

**(5) Iron** ore bodies apparently of some possible future importance are found in various places, and small quantities have been used for fluxing purposes by local smelters. In 1893-94 165 carloads were shipped from Nahant to the smelters of Omaha and Kansas City.

**(6) Tin** is present near Keystone in the southern part of the Hills and near Tinton in the northwestern part. Although efforts to develop the deposits have extended over more than 35 years, the production up to 1900 probably was not more than 50,000 lbs. of metallic tin. Since that date there has been a small production nearly every year.

**(7) Tungsten.** This recently valuable metal was discovered in 1899 near Lead and near Harney Peak. The production during that and the following year was about 140 tons.[22]

**(8) Manganese** ores have been discovered at several points. In 1892 19 tons were shipped from Custer county.

Antimony, bismuth, nickel, uranium, and several other metals are present in quantities sufficient to encourage prospecting, but as yet have not been valuable commercially.

### VI. Miscellaneous Mineral Products

Graphitic slates (pre-Cambrian in age) are abundant in many parts of the Hills, and in several places the content of graphite is sufficiently high to arouse interest in the economic possibilities of the deposits. Sixteen carloads of graphite were ground at the Mineral Paint works in Custer in 1900-01.[23]

For several years practically all the lithium minerals produced in the United States have come from the Custer district where the ores are found as lenses in pre-Cambrian pegmatite. The mineral spodumene arouses additional interest because of the vast size of some of its crystals. One showing in the sides of a drift for 36 feet, without break, is recorded.[24] Many have a diameter of more than three feet, and a length of more than six.

Mica quarries were exploited extensively during the 80's, and since 1900. The quarries and sorting plants near Custer include some of the larger quantities of high grade mica in that vicinity. Although the "Mineral Resources of the United States" states that South Dakota ranks second among the states, precise figures of production are not available.

### VII. Soils[25]

The general distribution of the chief types of soils is shown in Fig. 2.[26]

Most of eastern South Dakota has a clay-loam soil derived from the glacial drift of that area. This type is similar to that found in the parts of North Dakota, Minnesota, and Iowa which are free from loess, and has been named by the U. S. Bureau of Soils The **Carrington Clay-Loam.** Over extensive areas this soil is rich in humus, and hence is dark colored to the depth of a foot or so, and in depressions and on the lower parts of slopes, to the depth of two or more feet. This type of soil in South Dakota is considered to be superior in fertility to its representatives

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[22]O'Harra, C. C.: Mineral Wealth of the Black Hills, Bull. 3, S. D. Geol. Surv., p. 72, 1902. As yet the U. S. Geol. Survey has reported no production from S. D.

[23]Ibid., p. 72.

[24]Blake, W. P.: Mineral Resources of the U. S., U. S. Geol. Surv., p. 608, 1884.

[25]The more important references to literature on soils are: Coffey, G. N.: Reconnaissance Soil Map of Western South Dakota, Report of Field Work for 1909, U. S. Bureau of Soils, 1911. Todd, J. E., and Darton, N. H.: U. S. Geologic Folios, sections on soils. There is a general discussion of the soils of eastern South Dakota in McClure: The Resources of Dakota, (Aberdeen, 1887.)

[26]Based on Coffey's map.

in more humid areas, because nutritious salts are accumulated near the surface by the evaporation of soil moisture in semi-arid regions, while in humid regions the surface layers are depleted of salts by leaching.

The soil type perhaps next most widespread is the **Pierre clay,** derived by the weathering of the Pierre shale which outcrops widely (Fig. 1). In many places this clay is very compact, and when wet, very tenacious, and is called "gumbo." It does not absorb moisture readily, has a strong tendency to cake when dry, and locally possesses too large a content of certain minerals to be attractive to ordinary plants. For these reasons, gumbo is an undesirable soil, though it yields very abundantly in years when the precipitation falls at opportune times. Small gumbo areas, often popularly called "alkali spots," are found here and there even in the glaciated part of the state, and have been explained as the result of masses of Pierre shale which had been transported by the glacier after the manner in which bowlders were carried.[27] Small areas of this sort are being eliminated in many cases by building straw stacks over them. The straw, when decayed, contributes much mould, which counteracts the objectionable elements in the soil.

Clay-loams, silt-loams and sandy loams, grouped as "loams" in Fig. 2, derived from many rock formations, are widespread in western South Dakota. For reasons discussed in the chapter on Bio-geography, clay-loams are considered to be relatively the most productive in ordinary "wet years" (clays are most productive in years of unusually favorable precipitation), and silt-loams in dry years. The sandy soils have a fairly rank growth of native vegetation and do reasonably well by crops, but they blow badly during dry years after being broken up.

**Alluvium** is found in nearly all the larger valleys, and in most places is a desirable soil. Large sandy tracts are not numerous, and extensive gravelly areas are found almost exclusively in and near the Black Hills.

**Lacustrine silts** have accumulated to considerable depths in many basins in the glaciated part of the state. Most of the bed of glacial Lake Dakota is very fertile, partly for this reason.

Distinctly **eolian soils** are limited to (a) loess, which caps many hills in Lincoln and northern Union counties, (b) loess-like silt-loam found along the eastern bluff of the Missouri River, and (c) small dune areas in the south-central part of the state along the Missouri River near Elk Point, and at a few other scattered localities. Excepting the sandy parts, eolian soils are in good repute among agriculturists.

**Bowlders** are few except in the terminal moraine areas. In western South Dakota bowlders of a size to interfere with cultivation are of very local occurrence, chiefly on the flood-plains and terraces of streams heading in the Black Hills. Scattered fragments of concretions are met with in a few small areas. Belts of land which are quite stony, with angular fragments of flint, are distributed sparingly. There are large log-like sandstone concretions (Fig. 4) about some of the buttes in the northwestern quarter of the state, portions of which interfere with the tillage of some small areas.

[27]Todd, J. E.: The Elk Point Folio, (No. 156), U. S. Geol. Surv., 1907.

Fig. 4. Log-Like Concretion in the Ft. Union Formation, Harding County

# CHAPTER FOUR

## PHYSIOGRAPHY

General Features, p. 29; Prairie Plains, p. 32; Great Plains, p. 39; Black Hills, p. 43.

### I. General Features

Eastern South Dakota is a continuation of the prairies of Iowa and Minnesota. Most of the western half of the state is part of the Great Plains, but in the southwestern corner, an outpost (the Black Hills) of the Rocky Mountains rises conspicuously above the surrounding plains.

**(1) The Slope.** The general slope of the state is from west to east. In the western half of the state the principal rivers flow eastward and in the eastern half they flow southward.

**(2) The Relief.** The highest point is Harney Peak in the southern Black Hills. This peak is 7240 feet above sea level, an elevation greater than that attained by any peak in eastern North America. The lowest point is Bigstone Lake in the opposite corner of the state. Its elevation is 965 feet. The relief of the state is 6275 feet, exceeding that of any state farther east except North Carolina (6,711 feet), New Hampshire (6,290), and Tennessee (about 6300.)

Aside from the Black Hills and the small depression in the extreme northeastern corner, the relief is about 2600 feet or a half mile approximately.[1] Most of the eastern half of the state has a relief of less than 500 feet, and large areas have a relief of much less than this.

It appears that the mean elevation of the state is about 2,200 feet, the figure which, according to Murray's calculations, represents the average elevation of the lands of the globe. Out of the total area of 77,615 square miles there are approximately:

| | | |
|---|---|---|
| Below 1000 feet | 270 square miles or ..... | 0.3% of total area. |
| Between 1000-2000 feet | 42,300 square miles or | 54.5% of total area. |
| Between 2000-3000 feet | 23,000 square miles or | 30% of total area. |
| Between 3000-5000 feet | 10,700 square miles or | 13.5% of total area. |
| Between 5000-7000 feet | 1,380 square miles or | 2.8% of total area. |

**(3) Ruggedness.** Though possessing this considerable total relief, most of the state is far from rugged. The chief exceptions are parts of the Black Hills, parts of the White River and other badlands, and some of the lands along the deeper valleys. Thousands of square miles in the Dakota Valley are nearly level. The total area with slopes of more than 15° certainly is less than 15 per cent of the whole. Even in the Big Badlands along the upper White River more than 80 per cent of the area is tillable as far as slope is concerned since most of the steep-sided buttes are separated widely by nearly level stretches. Figs. 5 and 6 illustrate such a "flat." The Black Hills contain the largest untillable portion, but even in this mountainous area there are many farms along the fertile valleys and it is estimated that at least 5% of the area may be tilled.[2]

**(4) Drainage.** Most of the state lying east of a line which follows approximately the Missouri River across South Dakota (the line is shown on the soil map, (Fig. 2) was glaciated by the Dakota lobe of the last (Wisconsin) ice sheet, and has the topography characteristic of plains glaciated recently. It is covered by a layer of drift which averages about a hundred feet in thickness. Most of the surface of this part of the state is gently undulating. Exceptions are many nearly flat areas where

[1] The difference between 1100 feet in the Missouri Valley near Elk Point and 3700 feet on the higher buttes without the Black Hills.

[2] Prof. Jenny, quoted by McClure: Resources of Dakota, p. 166, (Aberdeen, 1887.)

Fig. 5. A view in the Badlands of Washington County; looking from Sheep Mountain towards the White River.

Fig. 6. An old ranch in the Badlands of Washabaugh County. The garden is irrigated by water secured from a copious spring.

former lakes have been filled, and several low terminal moranic belts, which locally are somewhat rugged. The average elevation of the eastern half of the state is about 1500 feet, but in the matter of elevation there are two distinct provinces (Fig. 7.) These are: (1) the broad Dakota Valley with an elevation of approximately 1300 feet, and (2) the east and west coteaus or divides on either side, with an average elevation approaching 2000 feet. These broad divides are mesa-like, rather steep-sided, and nearly flat-topped. The drainage of eastern South Dakota is very poorly developed, and there are thousands of shallow "lake-beds."

In the western half of the state, west of the Missouri River, the topography is in a mature stage of development, though there are broad terraces and tables, some of which are due to more resistant layers of rock, while others represent the tops of old peneplains developed in earlier cycles of erosion. On such uplands the slopes are very slight. The only undrained areas in this part of the state are the very shallow "blowouts" —basins made by the removal of the soil by wind. The rivers have cut rather deep valleys across the plains. Above the general level of the plains there are numerous conspicuous buttes and the Black Hills, while below it are the "badland basins" and most of the bad-land areas.

### 2. The Physiographic Provinces

Three main topographic subdivisions are rather distinct, namely, the Black Hills, the Great Plains, and the Prairie Plains. The Prairie Plains conveniently may be divided into three parts, namely, (1) the broad valleys in the southeastern corner, (2) the Dakota Valley, (3) the Coteaus, making a total of five subdivisions. The following map (Fig. 7) shows their location.

Fig. 7. Physiographic Provinces

## I. THE PRAIRIE PLAINS

### (I) The Southeastern River Valleys

The lower portions of the valleys of the Sioux, Vermilion and Missouri rivers are treated separately from the rest of eastern South Dakota, because (1) the broad flood-plains which comprise this subdivision are in distinct contrast with the rolling uplands on either side. These valleys lie for the most part some 50-100 feet below the South Dakota uplands, and from 200-400 feet below the adjacent uplands of Nebraska and Iowa. (2) Little of this subdivision was glaciated by the Wisconsin ice sheet, as was the rest of eastern South Dakota. (3) More abundant and reliable rainfall, a higher water-table, and a location which formerly made them more accessible than the remainder of the state from the East, have produced a somewhat distinct agricultural development and have given these valleys a prominence in the state which warrant a somewhat detailed treatment.

**(a) Position.** This irregularly shaped subdivision includes parts of several counties and nearly all of Union County. The limitations here adopted are indicated on fig. 7. The western limit is near Springfield, where the Missouri River leaves its post-glacial gorge—less than a mile wide, and enters a pre-glacial valley several miles wide. Similarly the Vermilion River below Centerville occupies a broad pre-glacial valley, while above that city its valley is much narrower. There is no definite northern boundary in the Sioux Valley. The glacial margin is indistinct, and the topographic changes gradual.

**(b) Area.** The area of this subdivision, is about 2000 square miles, or nearly the size of Delaware.

**(c) Topography.** The topography of this region is essentially plane. The elevation of the lowest part, near Sioux City, is 1100 feet. The gradient of the Missouri River in this region is about 6 inches per mile, or but half its average gradient across the state. In this province the Vermilion River has an average gradient of about 16 inches per mile, and the Sioux, irrespective of the falls and rapids near Sioux Falls, a gradient of more than two feet per mile. In spite of its lesser gradient, the Missouri River, because of its greater volume, has by far the swiftest current.

Natural levees are developed sufficiently well in each of the valleys to divert the tributary streams so that they enter their mains farther down stream than they otherwise would. The Vermilion and Sioux rivers themselves enter the flood-plain of the Missouri River several miles above the points where they join the master stream. The Elk Point quadrangle, within whose area these streams unite, affords therefore an excellent illustration of the barrier influence of even very low levees. Levees are one of the causes of extensive marshy lands within the Vermilion and Sioux valleys.

At present the Missouri River in this section is nowhere eroding the bluffs along its left bank, though it is under-cutting the western at many points. This may possibly be due to the influence of the rotation of the earth.[3]

The falls and rapids near the city of Sioux Falls owe their existence to a change in the course of that stream. Instead of continuing its southwestward course, it turns in the city and flows northward over an escarpment of Sioux Quartzite. North of the city it turns again and passing around the end of a range of morainic hills which extends a few miles east of the city, continues southward to the Missouri River near Sioux City.

[3]The larger the stream, the less local and temporary factors such as obstructions influence its course. Small streams like the Vermilion and Sioux are therefore less apt to show a predominance of erosion on their west bluffs than larger streams such as the Missouri River.

Fig. 8. The falls of the Sioux River in the city of Sioux Falls. The height of the chief falls is about 20 feet.

Fig. 9. A view across the Sioux River Valley towards the State Penitentiary. —Courtesy C. M. & St. P. R. R. Co.

This change in the course of the Sioux is ascribed to the las glacier.[4] A tongue of the Dakota lobe of ice reached a short distanc beyond Sioux Falls from the west, deposited the morainic hills referre to in the preceding paragraph, and damned the pre-glacial course of th river, which, as shown by a broad pre-glacial valley, had been by way o Centerville to the Missouri.

The Dalles and Palisades of the Sioux River and Split Rock Cree in Minnehaha and Moody counties are gorges which these streams hav eroded in the Sioux Quartzite. The walls are in places nearly vertica to the height of from 20 to 40 feet, and pinnacles of this resistant roc give certain evidence that these localities have not been glaciated recently

Picturesque erosional features (Fig. 8, 9) have given this area mor than a local reputation for scenic beauty.

## (2) THE DAKOTA VALLEY[6]

**(a) Location.** The Dakota Valley, as this term is used here, in cludes the broad, nearly level stretch of land which lies between th Wessington Hills, Ree Heights and Coteau du Missouri on the west, an

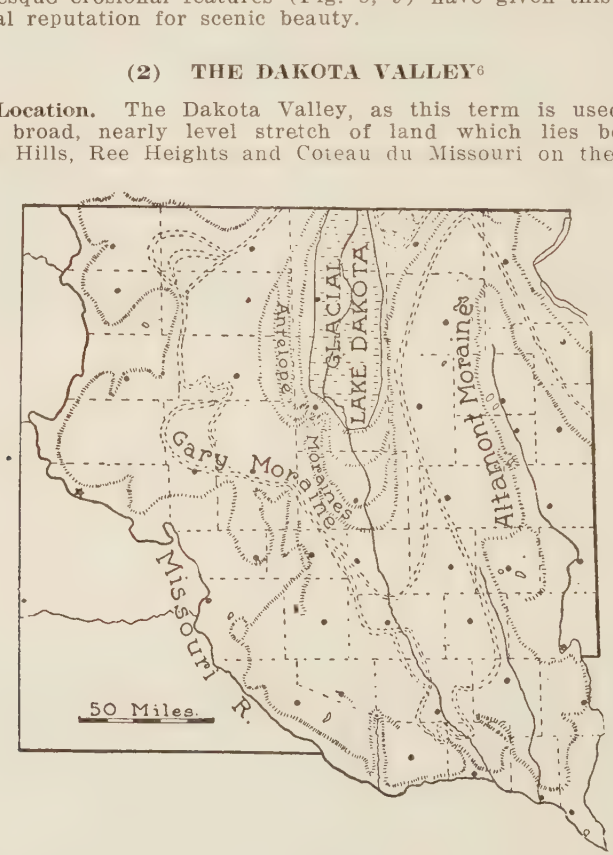


Fig. 10. The Glacial Moraines. (From Johnson's South Dakota.)

[4]Todd, J. E.: Bulls 144 and 158, U. S. Geol. Survey, 1896, 1899.

[5]Professor Todd informed me that Chamberlain, Leverett and he conclude after field examination together, that this area had not been glaciated in t glaciated period.

[6]A large part of the Dakota Valley has been mapped by the U. S. Geo ogical Survey. The following folios treat of areas which are within th province: Parker (No. 97); Olivet (No. 96); Alexandria (100); Mitchell (99 Huron (113); DeSmet (114); Aberdeen-Redfield (165); 1903-1909. In additi to these folios, Prof. Todd has treated of parts of this area in "the Geolo

the Coteau des Prairies on the east. It is a basin more than 200 miles long in South Dakota, and has an average width of more than 60 miles, and therefore an area of more than 15,000 square miles—larger than either Belgium, Denmark or Maryland, and half the size of North Carolina.

Brown, Spink, Beadle, Sanborn, Davison, Hanson and Hutchinson counties lie wholly within this province. The counties and parts of counties contained in this province are indicated on the outline map of the state dealing with the topographic provinces (Fig. 7.)

**(b) Topography.** The central part of the Dakota Valley from Huron to the North Dakota state line, is nearly level. This is due partly to glacial Lake Dakota which occupied this region. Elsewhere within this great valley the relief is that of a gently undulating ground moraine crossed by several low recessional moraines (Fig. 10.)[7]

The Dakota or James River[8] and some of its tributaries have trenched this basin only in its southern part (south of Huron.) Near its southern end,[9] there are gorges more than a hundred feet deep. These are somewhat serious obstacles to railroad building. The flood-plain of the Dakota River averages about a mile in width throughout the southern half of its course; and perhaps half a mile in the northern half of its valley.

Except in its central part, the Dakota Valley has many shallow, undrained depressions characteristic of ground moraine topography. Most of these swales are normally dry. Some of them usually contain small amounts of standing water, and popularly are called "sloughs." All the undrained depressions occasionally contain some water, since the sub-soil is so impervious that underground drainage is slow. There are few or no permanent lakes except in the recessional morainic belts, and these are small and shallow.

**(c) Relief.** With the exception of low cliffs about the deeper lake beds, and bluffs along streams in the southern half of the area, the relief is so slight throughout the Dakota Valley that each section line is followed by a road throughout nearly or quite its entire length. Railroad building therefore is comparatively simple. There are several stretches of straight track scores of miles in length, and many long sections have no bridges.

**(d) Elevation.** In elevation the Dakota Valley is peculiar in its uniformity—approximately 1300 feet. From Scotland (elevation 1300 feet) on the south to Aberdeen (elevation 1300 feet) nearly two hundred miles to the north, and at widely scattered intermediate localities selected at random (Mitchell 1300,, Woonsocket 1320, Huron 1290, Redfield 1300) the elevation is nearly the same. It is believed that in pre-glacial times the slope of most of the Dakota Valley was towards the north.[10]

The trenching by the Dakota River referred to in the previous

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and Water Resources of" (1) "a part of the lower James River Valley," (Water Supply Paper 90, U. S. Geol. Survey, 1904), (2) "a portion of southeastern South Dakota." (Water Supply Paper 34, 1900), and in Bulletins 1-3 of the South Dakota Geol. Survey, 1894-1902.

[7]For a discussion of the moraines see the Geologic folios and other references mentioned in the preceeding note.

[8]Although the National Geographic Board has adopted "James" rather than "Dakota" as the name of this stream, the latter name seems preferable and will be used in this publication for the following reasons: (1) There are several other James Rivers in the United States, (2) this river is wholly within the Dakotas, and its basin forms a large and highly important section of these states, (3) the act establishing Dakota Territory in 1863 specifically declared that "henceforth this stream shall be called the Dakota River," (4) very few of the local residents call it the "James" River, though many call it "the Jim.")

[9]See the Alexandria and Olivet sheets of the U. S. Topographic Atlas.

[10]Todd, J. E.: The Pleistocene History of the Missouri River, Science, pp. 264, 267, Feb., 1914.

paragraph supplies the slight gradient (six inches per mile across South Dakota[11]) possessed by that sluggish stream.

(e) In drainage, most of the Dakota Valley is defective. Of its approximately 15,000 square miles, probably less than one-fifth has exterior surface drainage—that is sends its runoff into outflowing rivers. The runoff of the remainder finds its way into swales or basins, from which most of its evaporates. Little sinks in, because of the relatively impervious glacial materials beneath the basins. At rare intervals the water in some of these basins, commonly called "lake-beds," overflows.

Most maps of South Dakota show several tributaries of the Dakota River. While the tributary valleys are in many cases well marked for twenty or thirty,—a few as much as fifty miles, yet the streams normally are insignificant. There are few if any tributary streams which flow throughout the year for more than a few miles above their junction with the main stream. Map publishers who show several conspicuous tributaries of the Dakota River doubtless are led to do so from analogy with more humid regions, rather than by the facts of the case.

The Dakota River itself was dry locally for a few days in 189 near Forestburg in Sanborn County; and has several times gone dry for a few days near Redfield in Spink County. It has been characterized as the longest unnavigable river in the United States.[12]

### (3) THE COTEAU REGIONS[13]

(a) The remaining and larger part of South Dakota east of the Missouri River here is included under the heading "The Eastern and Western Coteaus or Divides." The former, known as the Coteau des Prairies, or, more popularly, "the Lake region of South Dakota," is the lofty, nearly flat-topped, broad divide between the Dakota Valley on the west, and the Red, Little Minnesota, and lower Sioux valleys on the east. The Western Divide is between the Dakota Valley and the Missouri River. Its northern and more extensive portion is the southern end of the well marked divide in North Dakota, known as the Coteau du Missouri. The divide between the Missouri and Dakota valleys in South Dakota, is crossed by three broad pre-glacial valleys, and is therefore separated into four sections. From north to south there are (1) the extensive Coteau du Missouri proper, (2) Ree Heights, mostly in Hyde and Hand counties, (3) Wessington Hills, mostly in Jerauld County, and (4) Bijou Hills, mostly in Brule county. The coteaus are indistinct towards the southern part of the state.

The only counties located wholly on the east coteau are Codington, Deuel, Hamlin, and Lake. On the western divide are Campbell, Walworth, Potter, Sully, Hyde, Buffalo, Brule and Charles Mix counties. Portions of numerous other counties lie within this subdivision. (Fig. 7.

(b) The area included within this subdivision is nearly 20,000 square miles, or almost half the size of Ohio or Virginia.

(c) Topographically the coteaus may be considered as extensive mesas standing some 500 to 700 feet above the Dakota Valley which separates them. Just east of the eastern coteau are the Red River and

[11]Calculated from Gannett, Henry: Profiles of Rivers in the U. S., Bu 127, U. S. Geol. Survey.

[12]King's Handbook of the United States, p. 794, (Buffalo, N, Y., 1896

[13]There are no topographic maps of portions of this subdivision. Th references to publications dealing with this area are: Todd, J. E.: Th Moraines of the Missouri Coteau and their attendant deposits, Bull. 144, S. Geol. Survey, 1896. Todd, J. E.: The Moraines of S. E. South Dakota an their attendant Deposits, Bull. 158, U. S. Geol. Survey, 1899. Todd, J. E The Pleistocene History of the Missouri River, **Science**, Feb., 1914, pp. 26 274. Darton, N. H.: The Geology and Water Resources of South Dakot Water Supply Paper 227, U. S. Geol. Survey, 1909. Upham, Warren: Glaci Lake Agassiz, Monograph XXV, U. S. Geol. Survey, 1889.

Little Minnesota valleys with their head-waters in Lakes Traverse and Bigstone, more than 1000 feet below the summit of the coteau. The Missouri River, just west of the western coteau, is 300 feet below its summit to the north, and nearly 700 feet below the Bijou Hills at the south. The tops of these coteaus are somewhat even. Most of both were glacier-covered,[14] at least for a short time.

The eastern coteau lay between the Dakota and the Minnesota-Iowa lobes of the ice sheet, and is margined and crossed by the three chief terminal moraines[15] (Antelope, Gary, Altamont), which are interlobate moraines in portions of this area. (Fig. 10.)

**(d) Elevation.** In elevation, the summits over large areas of the eastern coteau reach approximately 2000 feet (1950-2050) to the northward of Lake county. Farther south the elevations decrease gradually to only 1500 feet in northern Union County. The western coteau has several extensive areas above 2000 feet, but the part known as Wessington Hills does not attain quite that elevation. The three broad valleys which cross this divide have maximum elevations of 1850 feet (at Hillsview between Aberdeen and Mobridge), 1650 feet (in the Ree Valley between Pierre and Redfield), and less than 1600 feet (between Chamberlain and Mitchell). Each of these valleys is taken advantage of by a railway.[16]

**(e) Drainage.** On the east coteau there are many lakes. The larger are lakes Waubay, Kampeska, Poinsett, Preston, Thompson and Madison. The western coteau has smaller lakes, fewer of which are permanent. This is due at least in part to increased aridity towards the west. The larger lakes on the western coteau are Wall, Andes, White and Red Lakes.

The coteaus are largely undrained as indicated by their numerous lakes and the absence of streams. The Chicago, Milwaukee & St. Paul Railroad between Madison and Bristol, about 90 miles, crosses not even a small creek or a bridge. However, short steep ravines are being eroded into the escarpments of several parts of the western coteau and at the head waters of the Little Minnesota River.

## GLACIAL LAKES

Three sorts of glacial lakes have been important in South Dakota. (1) Lakes due to the temporary damming of valleys which extended beyond the ice, but discharged towards it. Examples of this class were formed along the periphery of the ice sheet, especially on the west. Lake Arikaree was a large body of water which resulted from the union of smaller lakes developed in the valleys of each of several of the eastward flowing streams of that region.[17] Glacial Red Lake in Brule county, Glacial Lake Andes in Charles Mix county,[18] and Lake Agassiz[19] in the Red River Valley, a lake which reached a few miles southward into the northeastern corner of South Dakota, are other examples.

These lakes, as extensive bodies of water, were all of brief duration. In South Dakota the chief indications of their former existence are

[14]The Bijou Hills and the western portions of the Wessington Hills are exceptions.

[15]Todd, J. E.: Bulletins 144 and 158 of the U. S. Geol. Survey, 1896, 1899.

[16]For a discussion of valleys that cross the west coteau see various papers by Todd, J. E., the latest of which are "The Pleistocene History of the Missouri River," Science, Feb., 1914; "Glacial Channels in South Dakota," Bull. Geol. Soc. Am. Vol. 23, 1911; and "the Aberdeen-Redfield Folio," 1909.

[17]Todd, J. E.: The pleistocene History of the Missouri River, Science XXXIX, pp. 264, 273, 1914.

[18]Todd: Glacial Channels in Southeastern South Dakota, Bull. Geol. Soc. Am., Vol. 23, pp. 463, 470. 1911.

[19]Upham, Warren: Glacial Lake Agassiz, Monog. XXV, U. S. G. S., 1889.

(1) glacial bowlders floated by icebergs beyond the margin of the ice sheet, and (2) slight wave-cut terraces.

(2) Lakes due to erosion by the ice. Lakes Traverse and Bigstone are the only glacial lakes of South Dakota known to have rock basins. Many lakes on the drift may have been due to local erosion of the drift, or of the mantle rock which covered the solid rock when the ice came.

(3) Lakes due to unequal deposition of drift. To this class belong the vast majority of South Dakota's lakes. Glacial Lake Dakota,[20] which extended about 150 miles north from Mitchell and had an average width of 30 miles or more, was the largest lake of this class. It owed its existence to two morainic dams across the Dakota Valley, one near Mitchell, and the other across the former outlet to the northeast leading to the Red River Valley in southern North Dakota.

Most of the basins which ordinarily contain water are in the terminal or recessional morainic areas. The greater duration or permanence of water in these basins doubtless is favored by the fact that snow, which has been blown perhaps a score of miles across the plains, finds lodgment in the hollows of these more rugged morainic belts. Such hollows occasionally are drifted full of snow.

Basins that continue to have no outlet doubtless will accumulate sufficient salt to give to the water they may contain a brackish character. The reason why none in the glaciated section of South Dakota have yet reached that stage doubtless is due to (1) their youth, relative to the rate of salt accumulation, (2) to the accumulation of silt, which tends to bury, after each rain, any film of salt which may have been deposited previously. (3) An additional probably minor factor which will help explain the freshness of the water in the lake-beds of eastern South Dakota is that during the recurrent periods when the basins are dry, the wind tends to distribute widely the salt accumulated. The last two factors, though operative in western South Dakota, have not prevented the development of some alkali lakes. The glacial drift of eastern South Dakota probably has nearly as much salt in it as have the subsoils of most of the un-glaciated part of the state, as the formations underlying the drift over large areas in eastern South Dakota and North Dakota, whence the glacier came, are the same as outcrop widely in the un-glaciated part (Geologic map, Fig. 1.)

Most lakes are surrounded by a belt of bowlders. These probably were accumulated in the following ways: (a) The erosion of the shore of the lake by waves. The fine material of the drift worn away by waves was spread over the bottoms of the lakes, while the bowlders were left at the shore. (b) As the glacier melted back, some of the bowlders which had been in or on the glacier doubtless were floated out on icebergs and dropped chiefly near the margins where the icebergs grounded. (c) The thrust of the lake ice, often active in areas where the temperature ranges below 32° are pronounced, tends forcefully to concentrate the smaller bowlders on the margin. If after the lake is frozen over, the temperature falls greatly, as it frequently does in South Dakota, the ice contracts and is not sufficient to cover the lake. Cracks are formed in it, or much less frequently in shallow lakes, the ice is drawn away from the shore. The water which thus is exposed to the cold atmosphere soon freezes, and the lake again becomes ice covered. With the marked rise in temperature which follows the passage of the cold "snap," the ice covering expands greatly and becoming too large for the lake, exerts a powerful thrust on the shore, or buckles up, or both.[22]

[20]Todd, J. E.: The Aberdeen-Redfield Folio, U. S. Geol. Surv., 1909.
[21]Todd, J. E.: The Pleistocene History of the Missouri River, Science, XXXIX, p. 267, 1914.
[22]Salisbury, R. D.: Physiography, "Work of Lake Ice," (New York, 1908.)

Many lake-bed shores are distinctly steep. Their low cliffs at most points not more than a few feet high, probably are the result of the cutting of the waves supplemented by the thrust of the lake ice.

## II THE GREAT PLAINS[23]

The most extensive physiographic province of South Dakota is the Great Plains (Fig. 7.) This is the long slope from the foothills of the Black Hills and the western border of the state to the Missouri River.

(a) The area of the Great Plains in South Dakota is approximately 35,000 square miles or nearly one-half of the state. All of the counties of western South Dakota except Lawrence, lie entirely or partly within this province.

**(b) Topography.** It already has been stated that the western half of the state is in a mature stage of erosion, but that within the province there are extensive nearly level areas, called benches or tables, some of which represent former erosion levels and others the outcrop of more resistant horizontal rock formations. The general gentle eastward slope has been roughened by the erosion of running water. It is interrupted by somewhat deeply intrenched stream valleys, and, more conspicuously, by buttes. (Fig. 11.)

The more prominent buttes, named from the southern part of the state northward, are: Porcupine Peak, Eagles' Nest, Turtle Butte, Sheep Mt., Bigfoot Butte, Cedar Mt., White-Clay, Grindstone, Virginia and Rabbit Buttes, Fox Hills, Castle Rock, Deers Ears and Haystack Buttes. The larger, possessing considerable timber, are in Harding County, and are, in the same order, the Short Pine Hills, Slim Buttes, and Cave Hills.

The buttes are mostly on present or recent divides and have persisted because they were far from the main streams, and because of the presence of a resistant capping rock.

The steep-sided character of the buttes, which in no little degree is responsible for their conspicuousness, is the result of the cap rock, infrequent rains, and wind work. The wind has excavated a distinct depression around the base of many of the buttes, and in all cases has tended to prevent the accumulation of extensive talus. As a result of the extreme steepness, extensive slumping has taken place on the slopes

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[23]References to literature on this province are: The bulletins of the South Dakota Geological Survey all consider at least briefly this province: Bulletin 1 (1894), A Preliminary Report on the Geology of South Dakota, by J. E. Todd, treats very briefly of the plains. Bull. 2 (1898), contains reports by Prof. Todd on reconnoissance trips through southern counties, (pp. 117-135), and into the northwestern corner of the state (pp. 43-68). Bull. 3 (1902) has brief mention of this area in "Mineral Building Materials, Fuels and Waters of South Dakota, pp. 81-130, by J. E. Todd. Bull. 4 (1908) contains preliminary reports upon the geology of the northwest-central portion of South Dakota, by J. E. Todd (pp. 13-76, 193-207) and on Gregory and Tripp counties by E. C. Perisho (pp. 82-133). Bull. 5 (1912), dealing with the south-central part of the state, contains reports on the geography by S. S. Visher and on the geology by S. S. Visher and E. C. Perisho (pp. 31-60). Bull. 6 (1914), by S. S. Visher, is upon the biology of Harding County, but contains various references to the geography

Darton, N. H., in two government reports upon geology and water resources, (Prof. Paper 32 on The Great Plains, and Water Supply Paper 227 on South Dakota), makes brief mention of this section of South Dakota.

O'Harra, C. C.: The Bad Land Formations of the Black Hills Region, Bull. 9, S. D. School of Mines, 1910.

Perisho, E. C.: Science XXXIII, March, 1911, pp. 463-4 (Harding County, S. D.)

Coffey, G. N.: A Reconnaissance soil map of Western South Dakota, Report of Field Work for 1909, U. S. Bureau of Soils.

Todd, J. E.: The Hydrographic History of South Dakota, Bull. Geol. Soc. Am., Vol. 13 (1901), pp. 27-40.

Fig. 11. Thunder Butte, Ziebach County. A typical butte. Note the team and rig near the base of the butte.

of many of the buttes.[24] Basins which contain ponds have been produced by slumping on the flanks of Slim Buttes and the Short Pines Hills.

The summit areas of the forest-reserve-buttes of Harding County and Sheep Mountain in the Badlands total many square miles. Most of the other buttes have very limited flattish tops, and, therefore, have progressed much further on the road to extinction—the fate of all monadnocks.

Minor buttes are rather numerous. Mention has been made of the "Tepee Buttes" in the chapter on geology (p. 19.) They are in groups in certain sections, notably in parts of Harding, Meade, and Fall River counties, and decrease greatly the agricultural utility of the areas affected.

**(c) Elevation.** The 2000 foot contour follows up the tributaries of the Missouri River 15 to 20 miles from their mouths, but the divides are higher than 2000 feet almost to the Missouri River. The highest part of the plains, about 3700 feet, is on the Pine Ridge in Shannon county. About the same elevation is attained in the forested buttes of Harding County. The base of the outer rim of the foothills of the Black Hills has an elevation of from 3200 to 3500 feet. The average elevation of the Great Plains section is perhaps 2800 feet.[25]

(d) The drainage of this province is almost complete. There are five rivers which drain sub-equal areas. From north to south they are (1) Grand River,[26] (2) Moreau or Owl River,[27] (3) Cheyenne River,[28] (4) Teton or Bad River,[29] and (5) White River.[30]

The gradients of these streams are considerable—averaging from 8 to 10 feet per mile. The run-off therefore is very rapid in contrast with the streams in the eastern half of the state.

There are water-holes of two sorts on the plains. (1) the most numerous are small depressions which have been excavated by the wind. Most of these are only a few yards across and a few inches deep, though some have an area of several acres or more, and a depth of a few feet. Some of the larger ones locally are called lakes—Timber Lake in Dewey County being an example. The prevalent direction of their longer axes is northwest-southeast, from which direction come the stronger and more frequent winds during the seasons when the surface is dry and most easily excavated.

(2) Valley water-holes are also very numerous especially in the upper, shallower, parts of valleys. During times of very heavy rains, even these shallow valleys are filled with torrents which locally cut out little basins, which contain water for considerable intervals after showers, to the great advantage of mosquitoes, stock, and man.

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[24]Concerning slumping on the Slim Buttes see Winchester, D. E.: Cross-bedding in the White River Formation of N. W. So. Dak., Jour. of Geol., XXI, pp. 551-554, 1913. Concerning other buttes, see Perisho, E. C.: The Geology of Harding County, S. D., Science, R. S. Vol. XXXIII, p. 464, 1911. Concerning slumping along the Missouri River, see Todd, J. E.: Bull. 4, S. D. Geol. Shrvey, pp. 31, 32, 1908.

[25]There are detailed U. S. topographic maps of the section bordering the Black Hills only. The large maps of the state, Plates I and XI, in Darton's "Geology and Underground Waters in South Dakota" (Water-Supply paper 227, 1909) show contours of 250 feet interval.

[26]So-called by Lewis and Clark, because of the imposing scenery at its mouth.

[27]The Western Great Horned Owl seems to nest especially plentifully along the banks and bluffs of this stream.

[28]From "chien," the French word for dog—a name said to be given because of the many prairie dogs of the region.

[29]The Teton Indians occupied this valley at the time of the earlier voyagers. Lewis and Clark named this stream the Bad River because they were mistreated here by the Indians. The name has persisted because of the bad reputation of the stream for sudden flooding.

[30]From the color produced by the erosion of the badland beds.

**Badlands.**[31] Rugged areas, largely barren of vegetation, are found in various sections of western South Dakota. Such areas are popularly called badlands. The Big Bad Lands along the White and Cheyenne rivers in Stanley, Pennington, Mellette, Washabaugh, Washington, and Custer counties include perhaps 95 per cent of the more conspicuous badland areas of the state. Badlands are developed on the same geologic formation near the East Short Pine Hills and Slim Buttes in Harding county. Badlands on other formations are distributed widely, especially along the sreams and divides, and about the bases of buttes.

Badlands are not worthless lands: this is illustrated by Fig. 6 and proved by many farms and ranches. They were given this name because they were found by the Indians and early explorers[32] to be hard to cross. This is due to three main characteristics: (1) Most of the slopes are very steep, too steep to ascend or descend with a wagon, so that "the walls" and "jump offs" offer great obstacles to travelers unfamiliar with the region. (2) Many of the small gulleys have vertical banks, and in the absence of bridges, it may be necessary to go considerable distances in order to cross them. (3) Surface water in the badlands usually is scanty and uninviting to say the least, though not harmful. Shallow wells generally have good water.

The topography of the badlands—and South Dakota badlands are type badlands—is very interesting. The sculpturing is fascinating and suggests cathedrals, towers, statuary, haystacks, the billows of an ocean and many other objects.

Clays, marls, and sandstones, many of which are gaily colored, are exposed to view. These varied tints, in most cases reds, salmons or yellows, but in some places purples and whites, add greatly to the attractiveness of badlands.

"One approaching the badlands may gradually ascend a rolling, grassy surface, until he suddenly comes to a crest of ridge and finds himself gazing from a height of 200 to 400 feet upon a labyrinth of winding ravines and narrow ridges, which in some places widen into broad buttes capped with tables formed by harder strata or surmounted with slender pinnacles, reminding one of the spires of a cathedral. At other points the harder beds stand out as cornices and buttresses around the more prominent buttes. While this may appear near by, further away he may see graceful rounded domes and ridges, which remind one of hay-stacks or railroad embankments, where they continue as narrow ridges, with their tops extending upon the same level for some distances."[33]

Badlands are developed when certain conditions are combined. (1) The rainfall occasionally must come in heavy showers, or "cloudbursts" but must not be sufficiently abundant and regular to permit of a close vegetal cover. (2) The materials must be equally and incompletely indurated. In most places they are clays or shales with only relatively thin layers of sandstone or limestones. In South Dakota the Tertiary clays (especially the Oligocene clays) seem to be most favorable, though the bad-land type of topography is developed in semi-arid regions in many formations, during the early maturity stage of erosion (a third condition.)

On the steeper slopes of the badlands there is little vegetation.

[31]Recent publications on the badlands are: O'Harra, C. C.: The Badland Formations of the Black Hills Region, Bull. 9, South Dakota School of Mines, 1910, which summarizes previous publications; and Visher, S. S.: The Geography of south-central South Dakota, Bull. 5, South Dakota Geol. Survey, pp. 1-60, 1912; also Visher, S. S.: Erosion in the Badlands, The Journal of Geography, 1912.

[32]These areas were called La Mauvaise Terre by early traders, (Hale, Ed. E.: Kanzas and Nebraska, p. 67, N. Y., 1854), and Makochi, (land), Sica, (bad), by the Indians. (S. D. Dept. of Hist. Coll., Vol. VI, p. 274, 1912).

[33]Todd, J. E.: S. D. Geol. Surv., Bull. 1, p. 103, 1894.

This is due to (1) the rapid drying and extensive crumbling of the clay, thus preventing the growth of seedlings. (Fig. 12.) (2) During occasionally severe rain storms, the slopes are worn so rapidly that those plants which have obtained a start are undermined and usually killed.

Fig. 12. A rugged part of the Badlands, Stanley County

### Sand Hills

A strip a few miles wide along the southern border of Shannon, Bennett and Todd counties is occupied by sandhills similar to those which cover much of western Nebraska. In South Dakota the relief is moderate (about 20 feet), there are few lakes, almost none of which are alkaline, and relatively few of the hills are active dunes. Elsewhere in western South Dakota, where sandstones outcrop, notably in Todd, Tripp and Harding counties, there are areas of sandy soil in which, in most places, the local relief is slight, and the movement of sand by the wind is not extensive except where the sod has been destroyed.

## III. THE BLACK HILLS[34]

The Black Hills mass is a truncated dome about 100 by 50 miles in extent, nearly the size of Connecticut, two-thirds of which is in southwestern South Dakota, the other third in northeastern Wyoming. Several peaks, such as Harney, Terry, Custer, and St. Elmo, rise more than 6,500 feet above sea level. The limestone plateau near the South Dakota-Wyoming boundary is eroded less and is higher than most of the rest of the area, reaching a height of more than 7000 feet[35] Many canyons,

[34]There is an extensive literature on the geography and geology of the Black Hills. For a bibliography of 217 titles published before 1900 see O'Harra, C. C.: South Dakota School of Mines, Bull 4. More than two score "contributions" to the subject have been published since 1899. Darton, N. H.: Preliminary Description of the Geology and Water Resources of the southern half of the Black Hills, 21st Annual Report, U. S. Geol. Survey, Pt. 4, pp. 489-599, 1901; and The Geology and Water Resources of the Northern Black Hills, Prof. Paper 65, U. S. G. S., 1900, are excellent general treatments. Folios No. 85, 107, 108, 127, 128, 150, 165, of the U. S. G. S. J. D. Irving: Economic Resources of the Northern Black Hills, U. S. G. S., Prof. Paper No. 26. T. A. Jagger: Laccoliths of the Black Hills, U. S. G. S., 21st Ann. Rpt., Pt. III, are more detailed.

[35]Next to Harney Peak in elevation is the crest of this plateau a few miles to the northwest of this point is unnamed on the topographic maps, but locally is known as "Crooks Tower," (Tallent, A. D.: The Black Hills, p. 104, St. Louis, 1899).

some of them more than 1000 feet deep, add much to the picturesqueness of the Black Hills.

The Hills as a whole are a mountainous region which has an average elevation of more than 5000 feet, a rugged topography, extensive exposures of firm rock, and heavy forests, which as seen from the distance appear nearly black. This area is in distinct contrast to the surrounding less rugged grassy plain developed at an average elevation of perhaps 3000 feet on formations which are in most places poorly consolidated.

The Black Hills province is divisible into four distinct physiographic regions, three of which form zones which surround the fourth or central area. These are shown in a generalized cross section (Fig. 13.)

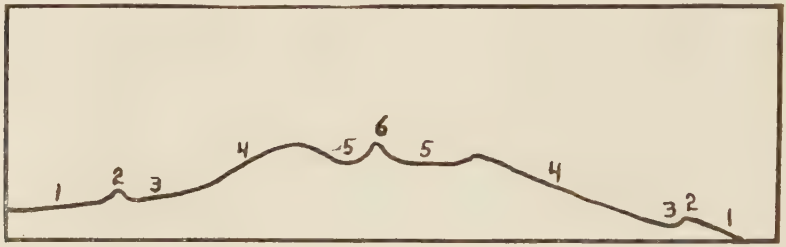


Fig. 13. A Diagramatic Cross-Section of the Black Hills

(2) The outermost are the hog-back ridges (cuestas) which form the foothills. Their crests reach an altitude of 4500 feet, and their slopes are too steep for cultivation.

(3) "The Red Valley," some 800-1000 feet lower, is in most cases only two miles or so wide, and is largely tilled.

(4) The "limestone country" zone, varying in width from two to more than 15 miles, and averaging nearly 6000 feet in elevation, forms a sort of plateau into which canyons are cut. The more notable canyons in South Dakota are those of Rapid, Boxelder, Elk and Spearfish Creeks, and Fall River. The limestone country is extensively forested but has some farms on terraces and on the gently sloping summit portions.

(5) The more open "park area," developed on the schist, slate, and igneous rock, has many broad valleys lower than the limestone plateau, but includes the higher peaks such as Harney, Terry, and Custer. There is a good deal of cultivated land in the broader valleys.

The drainage of the Black Hills is by tributaries of the Cheyenne River, forks of which nearly surround this area. The north fork is known as the Bellefourche River. The chief streams named from the south northward are Fall River, French Creek, Spring Creek, Rapid Creek, Box-elder Creek, Elk Creek, Spearfish Creek, Red-water Creek. Rapid and Spearfish creeks are the larger.

The gradients of the streams are what might be expected in a low mountainous area. Falls, however, are infrequent. A tributary (the little Spearfish) falls over a limestone deposit some 30 feet into Spearfish canyon.[36] Fall river has a low fall over a resistant ledge of rock.

Sink holes are few, and confined mainly to the thin limestone overlying the red-beds. There are caves, however, in the other limestones. Crystal Cave in Elk Canyon and Wind Cave[37] near Hot Springs are both rather extensive, and there are many smaller ones. They seem to have been developed before the extensive dissection of the anticline dome by sub-aerial erosion had taken place.

[36]Todd, J. E.: Bull. 2, S. D. Geol. Survey, pp. 80, 81, 1898.
[37]Todd, J. E.: Bull. 1, S. D. Geol. Survey, pp. 48-50, 1894; Bull. 2, p. 72 1898.

Although the Black Hills lack snow capped peaks and some of the magnificent grandeur of more lofty and rugged mountains, they possess a great deal of scenic beauty. In contrast with the dry plains which extend for at least a hundred miles in each direction, they are very attractive. The Harney range is the part which is most picturesque from a distance. "From the east it suggests a vast mass of thunder clouds rising along the western horizon. Seen from the height south of Custer, the crest of the range has much the appearance of a saw lying with teeth upwards; and a view from the northeast presents a wonderful landscape of lofty mountain peaks, tremendous precipices, and a vast and almost inaccessible wilderness."[38] From the peak itself "we see a wilderness of wooded peaks encircled by a broad valley, the Red Valley, which the Indians call the Race course, this in turn enclosed by a wall of foothills. All is curiously symmetrical a castle of geologic dimensions, with domes and turrets and a broad moat within its ramparts."[39] Fifty miles to the southeast, the milk-white cliffs of the badlands can be seen. Nearly as far to the north-northeast whitish Bear Butte stands conspicuous just beyond the dark pine forest. Eighty miles to the north, several lesser buttes including Deers Ears and Castle Rock, may be seen through the haze. To the northwest the mountainous landscape is continued by the Bearlodge Mountains. The light colored area therein is the granitic culmination, Warrens Peaks. To the west, more than a hundred miles distant, the Bighorn mountains may be seen occasionally, it is said

[38]Andreas, A. T.: Historical Atlas of Dakota, p. 107, (Chicago, 1884).
[39]Ogden, A.: A Ride Through the Black Hills, Atlantic Monthly, April, 1892, p. 455.

Fig. 14. One of the thousands of superb views of the Black Hills

Fig. 15. The famous Granite "Needles" near Harney Peak and Sylvan Lake in the southern Black Hills.

Fig. 16. Bear Butte, near the northeastern corner of the Black Hills—a striking landmark.

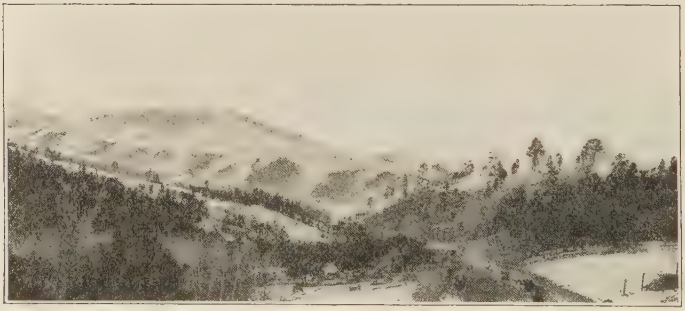

Fig. 17. In the foothills of the Black Hills near Sturgis

Fig. 18. Slyvan Lake. A view in the Granite Area near Harney Peak, Custer County.

# CHAPTER FIVE

## THE CLIMATE

General Characteristics, p. 50; Factors determining, p. 50; Winds, p. 50; Temperature, p. 53; Length of Day, p. 58; Humidity, p. 59; Evaporation, p. 60; Cloudiness, p. 60; Precipitation, p. 60; Variability of weather, p. 66; Supposed changes in climate, p. 67.

### I. General Characteristics

The climate is invigorating. Clear skies and stimulating breezes prevail. Though great ranges of temperature occur, the dryness of the atmosphere helps to keep the sensible temperatures more nearly uniform. The summer season is usually long and warm enough for raising corn. The normal annual precipitation is sufficient for the crops grown.[1] The seasonal distribution of precipitation is very favorable, since slightly more than three quarters normally fall during the six months, April-October 1. The autumns and winters have relatively little precipitation, to which fact is due the naturally-cured hay furnished by the native grasses, as heavy autumn rains, when they occur, leach out much of the nutrition. The "openness" of the winters encourages grazing and permits a greater amount of social intercourse among the rural population than could be the case were there deep snows.

The chief climatic handicaps are: (1) irregularity in the amount and distribution of precipitation; and (2) unseasonable low temperatures in the growing season. Periods of drought are common, but the southeastern quarter of the state never has had a general failure of both the corn and small grain crops. In the western part of the state especially, the normal amount of rain in some years may fall in such short, heavy showers that most of it runs off and thus is of little benefit to the crops. Late killing frosts in the spring are not infrequent and are a menace to fruit growing and occasionally injurious to corn. Early autumn frosts occasionally damage corn and flax crops especially in the northern sections.

### 2. Factors Determining the Climate

The climate of South Dakota is determined by (1) the latitude, (2) the position of the state in the continental interior, and (3) the winds. The position of South Dakota gives it a continental type of climate with hot summers and cold winters, and means remoteness from sources of moisture. Because of the latitude (43°-46°) the days are long during the growing season. The state is located within the belt of prevailing westerly winds and is affected by many of the cyclonic storms which cross the continent in that belt. The winds are the chief agents in the distribution of moisture. They also greatly influence temperatures and relative humidity.

### 3. Winds

Northwest winds prevail during the colder six months and southeast winds during the warmer six months. Winds from other directions are of relatively short duration.[2] The prominence of northwest and southeast

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[1] If 8 inches of water are available for the use of growing wheat, its moisture requirements are filled. In no section of the state is the amount of rainfall normally received during the growing season as low as 11 inches (81 per cent of 14 inches). Since the runoff in large sections is considerable and the rate of evaporation is very rapid, agricultural practices which conserve the moisture (dry farming) generally are necessary in the drier portions of the state.

[2] There is an exception at Rapid City, due to its location just east of a gap through a lofty ridge which deflects the wind from northwest to west, resulting in a prevailing west wind.

winds is due to the influence of cyclonic storms whose centers pass eastward over or near South Dakota.

Most of the winds are of moderate velocity—the average being about ten miles an hour. There are very few calm days, about 10 in the year, though calm nights are frequent. In the valleys and lowlands the wind often increases in force as the day advances and dies down at nightfall, but this is not often the case on buttes.

The persistent and moderate velocities of the wind favor the use of windmills, which have become very numerous except where artesian flows may be obtained readily.

The rate of evaporation is higher than it would be if winds were less persistent. Thus they strongly influence sensible temperatures and increase transpiration from vegetation, making the water requirements of crops somewhat greater than in sections having less wind.

**(a) Wind Velocities.** The average wind velocity, (in miles per hour) for the most windy and the least windy months at four South Dakota and one northern Nebraska station is shown by table 1.[3]

**Table 1. Average Wind Velocity in Miles per Hour**

| | Section of State | April | July | Year |
|---|---|---|---|---|
| Huron, S. D. | East | 13.8 | 10.4 | 11.6 |
| Pierre, S. D. | Central | 12.1 | 9.2 | 9.3 |
| Rapid City, S. D. | West | 9.3 | 7.5 | 8.1 |
| Yankton, S. D. | S. E. | 10.8 | 6.4 | 8.4 |
| Valentine, Neb. | N. Cent. | 13.0 | 10.0 | 11.0 |

The differences between the several stations appear to be due to differences in local conditions. Huron and Valentine are located on nearly level plains. The other stations are protected somewhat, Pierre from east winds by the bluffs along the Missouri Valley in which this city is located, and Rapid City from northwest and southwest winds by foothills of the Black Hills (Fig. 42.)

**(b) Gales.** For the decade 1891-1900 Pierre had an annual average of 18.8 days with gales;[4] Huron an average of 35.7 days, and Sioux City, Iowa, 27.3 days. The months with the most numerous gales and the average number in each for that decade is shown by table 2.[5]

**Table 2.**—Monthly Distribution of Gales during the ten years 1891-1900.

| Station | NW | N | NE | E | SE | S | SW | W | Total |
|---|---|---|---|---|---|---|---|---|---|
| Pierre, S. D. | 80 | 21 | 15 | 16 | 17 | 13 | 3 | 23 | 188 |
| Huron, S. D. | 97 | 10 | 10 | 3 | 143 | 52 | 15 | 27 | 357 |
| Sioux City, Ia. | 138 | 22 | 1 | 5 | 21 | 70 | 10 | 6 | 273 |

**Table 3**—Total number of days with gales—winds of 40 miles per hour and over from the direction as indicated during the ten years 1891-1900.

| Station | Jan. | Feb. | Mch. | Apr. | May | Ju. | July | Aug. | Sep. | Oct. | Nov. | Dec. | Ann. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pierre, S. D. | 13 | 11 | 17 | 18 | 22 | 28 | 19 | 17 | 13 | 14 | 10 | 6 | 188 |
| Huron, S. D. | 22 | 17 | 33 | 49 | 43 | 42 | 25 | 18 | 39 | 27 | 27 | 15 | 357 |
| Sioux City, Ia. | 20 | 29 | 29 | 42 | 32 | 26 | 12 | 11 | 20 | 19 | 16 | 17 | 273 |

[3]Summaries of Climatological Data of U. S. Bull. W., U. S. Weather Bureau, Sects. 33, 34, 35.

[4]Gales as defined in the report from which these data are taken are winds of more than 40 miles per hour.

[5]Tables 2 and 3 are from Henry, A. J., The Climatology of the United States. Bull. Q., U. S. Weather Bureau, p. 74, 1906.

When gales are associated with low temperatures and snow the result is a blizzard. When they are associated with high temperatures and low humidity they become blasting "hot winds."

The fact that the prevailing direction of the stronger winds has influenced the shape of blowouts has been noted in the physiographic section.

(c) **Tornadoes,** often called cyclones, sometimes occur in South Dakota, especially in the southeastern quarter. They are very irregular in their distribution. Several years may pass without any, and then there may be several in one year. They are the most destructive type of storm known, but happily the area affected is very restricted. Even in the states most affected by tornadoes, the probability that a given square mile will be crossed has been calculated at much less than 1-16 of one per cent per century.[6]

(d) **Blizzards.** The blizzard is a much less frequent visitor than is generally supposed by non-residents, and as a result of the conditions attending the settlement of the rural districts, the construction of more commodious and more substantial farm buildings, fencing, and the more complete preparation for winter, such storms should be much less injurious than formerly.[7]

The blizzards that gave Dakota a reputation for severe winters were those of the days of the early settlement of the territory when the homesteaders in their temporary quarters were ill prepared for storms. The last blizzard which caused much destruction was in 1888. After several mild days it commenced to snow and blow very hard on January 12-13 (it took a day for the storm to travel from Pierre to Yankton.) Two or three feet of snow fell in an hour or two, after which the temperature fell to -30° and the wind increased its velocity to 40 miles per hour. The snow drifted phenomenally as the high wind continued until many buildings were nearly filled with snow through even very small openings. Railroad and wagon travel was interrupted at many points. For several weeks many domesticated, as well as wild, animals suffered for lack of food, and some thousands of the weaker animals died. It is reported that 112 human lives were lost in what is now South Dakota as a result of this storm.[8] By means of the telegraph and telephone, warning can now be sent out widely, so that some special preparation may be made since severe storms approach slowly.

(e) **Hot Winds.** It is not unlikely that the extension of the tilled area has reduced the injury inflicted on any given locality by hot winds, because cultivated fields, now very extensive, absorb the rainfall much more completely than did the native turf. While formerly much of the rainfall ran off into sloughs or stream channels, now a larger per cent is retained in the sub-soil of the extensive tilled areas and forms a reservoir from which the crops draw. Nevertheless winds which are very drying still occur, and if their occurrence coincides with a period of deficient soil-moisture, vegetation suffers severely, especially sorts which are unable to absorb water approximately as rapidly as it is transpired. Some crop is ruined in some parts of the state nearly every year by a hot wind at a critical time. In 1911 a hot wind which persisted for several hours blasted, in several counties centering about Hyde County, wheat which was "in the milk." No attempt was made to harvest such fields. Certain animals, notably some amphibians, and insects which are in the larval stage or have recently pupated, are killed in some cases by excessively rapid evaporation.

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[6]Henry, A. J.: The Climatology of the U. S., Bull. Q., U. S. Weather Bureau, p. 77, 1906.

[7]Glenn, S. W.: Summary for Sect. 34, U. S. Weather Bureau, p. 2, 1909.

[8]Robinson, Doane: Outline of South Dakota's History, S. D. Dept. of Hist. Coll. Vol. II, p. 99, 1904.

### 4. Temperature

**(a) Mean Annual.** Fig. 19 is a map showing the average annual isotherms for the state. The mean annual temperature of the state is about 45°,[9] for the eastern half about 44.5°, and for the western half about 45.6°. The northern counties have an annual mean about 5° lower than the southern counties. For reasons to be discussed, the northeastern quarter of the state is the coldest and the southeastern the warmest (while the southwestern has the least cold in winter.) Greenwood in Charles Mix county, however, for many years reported the highest monthly and annual mean. The coldest station is Roslyn in Day County. Winds which are warmed by descent from the Rocky Mountains, but which soon lose their excess heat, make the western half of the state

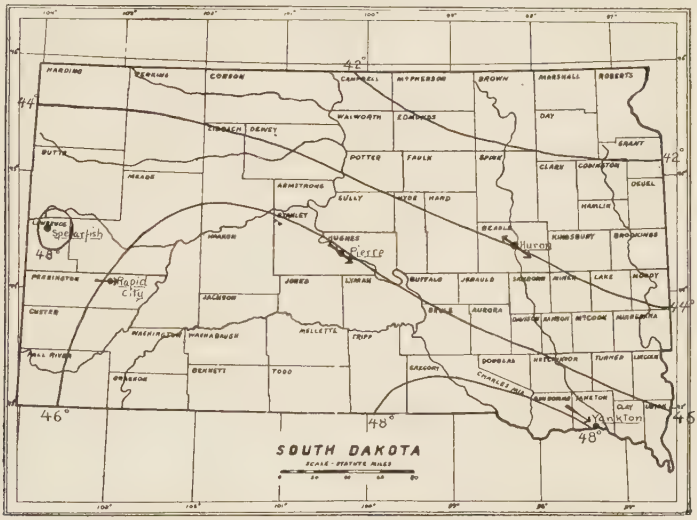


Fig. 19. Map showing the more important Weather Bureau Stations; the prevailing wind direction; and the average annual temperature.

warmer than the eastern. Local topographic conditions at Greenwood in the Missouri Valley and at Spearfish in the Black Hills favor temperatures nigher than normal at nearby stations. The Black Hills are a complicating factor in respect to temperatures.

**(b) Mean Monthly Temperatures.** The mean monthly temperatures for Huron, Pierre, and Rapid City are as follows:[10]

**Table 4—Mean Monthly Temperatures**

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Huron (1882-1905) | 9.5 | 12.9 | 26.7 | 44.6 | 57.3 | 66.6 | 71.5 | 69.1 | 59.6 | 44.7 | 27.4 | 15.7 |
| Pierre (1892-1905) | 13.9 | 16.9 | 29.5 | 46.5 | 59.3 | 68.9 | 75.2 | 73.1 | 62.8 | 49.1 | 31.6 | 20.1 |
| Rapid City (1888-1905) | 21.5 | 23.5 | 31.6 | 43.5 | 54.2 | 13.8 | 70.2 | 68.8 | 59.1 | 46.6 | 33.6 | 26.0 |

[9]All temperatures are in degrees Fahrenheit.
[10]Bigelow, F. H.: The Daily Normal Temperature and Daily Normal

For the state as a whole, the average temperature for July, the warmest month, is about 72°; for January, the coldest, about 13°. August is nearly as warm as July, and February nearly as cold as January; in fact many of the lowest temperatures have been recorded in February.

**(c) Mean Daily Temperatures.** The following tables give the daily normal temperatures at Huron and Rapid City:[11]

**Table No. 5.—Daily Normal Temperature—Huron S. D. 1882-1905**

| Day | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 | 10 | 18 | 37 | 52 | 63 | 70 | 72 | 65 | 53 | 35 | 21 |
| 2 | 11 | 10 | 18 | 37 | 52 | 63 | 70 | 72 | 65 | 52 | 34 | 20 |
| 3 | 10 | 10 | 19 | 38 | 53 | 63 | 70 | 71 | 64 | 52 | 34 | 20 |
| 4 | 10 | 10 | 19 | 39 | 53 | 64 | 70 | 71 | 64 | 51 | 33 | 20 |
| 5 | 10 | 10 | 20 | 39 | 53 | 64 | 71 | 71 | 64 | 51 | 33 | 19 |
| 6 | 10 | 11 | 21 | 40 | 54 | 64 | 71 | 71 | 64 | 50 | 32 | 19 |
| 7 | 10 | 11 | 21 | 40 | 54 | 64 | 71 | 71 | 63 | 50 | 32 | 19 |
| 8 | 10 | 11 | 22 | 41 | 54 | 65 | 71 | 71 | 63 | 49 | 31 | 18 |
| 9 | 10 | 11 | 23 | 41 | 55 | 65 | 71 | 71 | 62 | 49 | 30 | 18 |
| 10 | 10 | 11 | 23 | 42 | 55 | 65 | 71 | 71 | 62 | 48 | 30 | 18 |
| 11 | 9 | 12 | 24 | 42 | 56 | 66 | 71 | 70 | 62 | 48 | 30 | 18 |
| 12 | 9 | 12 | 24 | 43 | 56 | 66 | 71 | 70 | 61 | 47 | 29 | 17 |
| 13 | 9 | 12 | 25 | 43 | 56 | 66 | 71 | 70 | 61 | 47 | 28 | 17 |
| 14 | 9 | 12 | 26 | 44 | 57 | 66 | 72 | 70 | 60 | 46 | 28 | 17 |
| 15 | 9 | 13 | 26 | 45 | 57 | 67 | 72 | 70 | 60 | 46 | 27 | 16 |
| 16 | 9 | 13 | 27 | 45 | 57 | 67 | 72 | 70 | 60 | 45 | 27 | 16 |
| 17 | 9 | 13 | 27 | 46 | 58 | 67 | 72 | 69 | 59 | 44 | 26 | 16 |
| 18 | 9 | 14 | 28 | 46 | 58 | 67 | 72 | 69 | 59 | 44 | 26 | 15 |
| 19 | 9 | 14 | 28 | 47 | 58 | 68 | 72 | 69 | 58 | 43 | 25 | 15 |
| 20 | 9 | 14 | 29 | 47 | 59 | 68 | 72 | 68 | 58 | 43 | 25 | 14 |
| 21 | 9 | 15 | 30 | 48 | 59 | 68 | 72 | 68 | 58 | 42 | 25 | 14 |
| 22 | 9 | 15 | 30 | 48 | 60 | 68 | 72 | 68 | 57 | 41 | 24 | 13 |
| 23 | 9 | 15 | 31 | 49 | 60 | 68 | 72 | 68 | 56 | 41 | 24 | 13 |
| 24 | 9 | 16 | 32 | 49 | 60 | 69 | 72 | 68 | 56 | 40 | 23 | 12 |
| 25 | 9 | 17 | 33 | 49 | 60 | 69 | 72 | 67 | 56 | 40 | 23 | 12 |
| 26 | 9 | 17 | 34 | 50 | 61 | 69 | 72 | 67 | 55 | 39 | 22 | 12 |
| 27 | 10 | 17 | 34 | 50 | 61 | 69 | 72 | 67 | 55 | 38 | 22 | 12 |
| 28 | 10 | 17 | 35 | 51 | 61 | 71 | 72 | 66 | 54 | 38 | 22 | 11 |
| 29 | 10 | .. | 36 | 51 | 62 | 70 | 72 | 66 | 54 | 37 | 21 | 11 |
| 30 | 10 | .. | 36 | 52 | 62 | 70 | 72 | 66 | 53 | 36 | 21 | 11 |
| 31 | 10 | .. | .. | .. | .. | .. | 72 | 65 | .. | 36 | .. | .. |
| Mean | 9.5 | 12.9 | 26.7 | 44.6 | 57.3 | 66.6 | 71.5 | 69.1 | 59.6 | 44.7 | 27.4 | 15.7 |

Ann. Mean equals 42.1.

Precipitation of the U. S., Bull. R., U. S. Weather Bureau, pp. 41, 72, 1908.

[11]Ibid., p. 41, 72.

**Table 6.—Daily Normal Temperature—Rapid City 1888-1905**

| Day | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23 | 22 | 26 | 38 | 49 | 59 | 68 | 71 | 64 | 53 | 39 | 29 |
| 2 | 23 | 22 | 27 | 38 | 50 | 60 | 68 | 71 | 64 | 53 | 39 | 29 |
| 3 | 22 | 22 | 27 | 39 | 50 | 60 | 69 | 71 | 64 | 52 | 38 | 28 |
| 4 | 22 | 22 | 27 | 39 | 50 | 60 | 69 | 71 | 63 | 52 | 38 | 28 |
| 5 | 22 | 22 | 28 | 39 | 51 | 61 | 69 | 71 | 63 | 52 | 37 | 28 |
| 6 | 22 | 22 | 28 | 40 | 51 | 61 | 69 | 71 | 63 | 51 | 37 | 28 |
| 7 | 22 | 22 | 28 | 40 | 51 | 61 | 69 | 71 | 62 | 51 | 37 | 28 |
| 8 | 22 | 22 | 29 | 41 | 52 | 62 | 70 | 71 | 62 | 50 | 36 | 27 |
| 9 | 22 | 22 | 29 | 41 | 52 | 62 | 70 | 71 | 62 | 50 | 36 | 27 |
| 10 | 22 | 22 | 29 | 41 | 52 | 62 | 70 | 70 | 61 | 49 | 35 | 27 |
| 11 | 22 | 23 | 30 | 42 | 53 | 62 | 70 | 70 | 61 | 49 | 35 | 27 |
| 12 | 21 | 23 | 30 | 42 | 53 | 63 | 70 | 70 | 60 | 49 | 35 | 27 |
| 13 | 21 | 23 | 30 | 43 | 53 | 63 | 70 | 70 | 60 | 48 | 34 | 27 |
| 14 | 21 | 23 | 31 | 43 | 54 | 63 | 70 | 70 | 60 | 48 | 34 | 27 |
| 15 | 21 | 23 | 31 | 43 | 54 | 64 | 70 | 70 | 59 | 47 | 34 | 27 |
| 16 | 21 | 24 | 32 | 44 | 54 | 64 | 71 | 69 | 59 | 47 | 33 | 26 |
| 17 | 21 | 24 | 32 | 44 | 55 | 64 | 71 | 69 | 59 | 46 | 33 | 26 |
| 18 | 21 | 24 | 32 | 45 | 55 | 65 | 71 | 69 | 58 | 46 | 32 | 26 |
| 19 | 21 | 24 | 33 | 45 | 55 | 65 | 71 | 68 | 58 | 46 | 32 | 26 |
| 20 | 21 | 24 | 33 | 45 | 56 | 65 | 71 | 68 | 57 | 45 | 32 | 25 |
| 21 | 21 | 24 | 33 | 46 | 56 | 66 | 71 | 68 | 57 | 44 | 31 | 25 |
| 22 | 21 | 25 | 34 | 46 | 56 | 66 | 71 | 68 | 57 | 44 | 31 | 25 |
| 23 | 21 | 25 | 34 | 46 | 56 | 66 | 71 | 67 | 56 | 44 | 31 | 24 |
| 24 | 21 | 25 | 35 | 47 | 57 | 66 | 71 | 67 | 56 | 43 | 30 | 24 |
| 25 | 21 | 25 | 35 | 47 | 57 | 67 | 71 | 67 | 56 | 42 | 30 | 24 |
| 26 | 21 | 26 | 35 | 48 | 57 | 67 | 71 | 66 | 55 | 42 | 30 | 24 |
| 27 | 21 | 26 | 36 | 48 | 58 | 67 | 71 | 66 | 55 | 42 | 30 | 24 |
| 28 | 22 | 26 | 36 | 48 | 58 | 67 | 71 | 66 | 54 | 41 | 30 | 23 |
| 29 | 22 | .. | 36 | 48 | 58 | 68 | 71 | 65 | 54 | 40 | 29 | 23 |
| 30 | 22 | .. | 37 | 49 | 59 | 68 | 71 | 65 | 54 | 40 | 29 | 23 |
| 31 | 22 | .. | 37 | .. | 59 | .. | 71 | 65 | .. | 40 | .. | 23 |
| Mean | 21.5 | 23.5 | 31.6 | 43.5 | 54.2 | 63.8 | 70.2 | 68.8 | 59.1 | 41.6 | 33.6 | 26.0 |

Ann. Mean equals 45.2.

From the above tables it may be observed that at Huron there are 67 days (June 19-August 24 inclusive) with a normal temperature of 68° or above and at Rapid City 55 such days (June 29-August 22.) At Huron there are 165 days (5½ months) with the daily normal temperatures 50° or above and at Rapid City 161 days (May 2-October 9 inclusive.) Both stations have about sixteen weeks during which the daily normal temperature is below 32°. Rapid City has no day with a normal temperature below 20°, while Huron has 90 such days, and 33 days with normal temperature of 10° or lower. The temperatures at Rapid City are influenced by its situation at the eastern edge of the Black Hills where chinook winds often are strongly developed.

**(d) Maxima and Minima Temperatures.** Mean and extreme maxima and minima temperatures are of great significance to life—they, rather than **average** temperatures influence physiological activities and apparently limit the range of species. Maxima temperatures of over 100° have been recorded for most of the stations, outside the Black Hills, and minima temperatures below -40° have been recorded from most of the long established stations except those in the Black Hills region. The extremes for the state are 115° and -50°—a range of 165°. Several stations have recorded an annual range of more than 150°.

**Table 7.—Mean and Extreme Maxima Temperatures for Certain Months[12]**

| | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|
| Aberdeen, Mean Max. | 90 | 99 | 99 | 98 | 94 |
| Absolute Max. | 96 | 104 | 107 | 111 | 102 |
| Huron, Mean Max. | 89 | 96 | 98 | 98 | 94 |
| Absolute Max. | 96 | 99 | 108 | 108 | 106 |
| Yankton, Mean Max. | 92 | 97 | 99 | 97 | 96 |
| Absolute Max. | 95 | 102 | 107 | 105 | 104 |
| Pierre, Mean Max. | 91 | 102 | 101 | 102 | 97 |
| Absolute Max. | 98 | 103 | 108 | 110 | 104 |
| Rapid City, Mean Max. | 85 | 96 | 97 | 97 | 92 |
| Absolute Max. | 92 | 103 | 102 | 106 | 102 |

**Table 8.—Mean and Extreme Minima Temperatures for Certain Months[12]**

| | Nov. | Dec. | Jan. | Feb. | Mar. | |
|---|---|---|---|---|---|---|
| Aberdeen, Mean Min. | 1 | —16 | —31 | —21 | —1 | |
| Absolute Min. | —25 | —28 | —34 | —46 | —31 | 0 |
| Huron, Mean Min. | 4 | —14 | —29 | —18 | 3 | |
| Absolute Min. | —28 | —34 | —43 | —37 | —25 | 7 |
| Yankton, Mean Min. | 9 | —4 | —20 | —14 | 6 | |
| Absolute Min. | —18 | —34 | —32 | —33 | —18 | —3 |
| Pierre, Mean Min. | 9 | —7 | —21 | —11 | 3 | |
| Absolute Min. | —16 | —19 | —30 | —40 | —15 | 5 |
| Rapid City, Mean Min. | 0 | —9 | —19 | —11 | 3 | |
| Absolute Min. | —9 | —24 | —30 | —34 | —17 | —2 |

The high maxima in South Dakota stimulate growth in some plants, notably corn, as long as sufficient moisture is available. If that fails, many plants promptly wither. Winds accompanying high temperatures frequently are 'hot winds," although such winds are not necessarily confined to days having high maxima. Where daily maxima of 100° to 110° occur in summer, as in most of the state, they may be expected not infrequently. These winds cause such rapid evaporation that plants which cannot absorb through their roots fast enough to equal the transpiration soon wilt. Plants acclimated to more humid regions may wither at such times, while there still is an abundance of soil moisture for plants differently constituted.

The influence of the extremely low minima temperatures in South Dakota is less clearly injurious than in the case of the maxima. Freezing pulverizes the soil by rupturing the cohesion between many soil particles. In extremely cold weather, however, cracks more than three feet deep may be opened and aeration and deeper freezing permitted. Various plants are barred from the state because of the winter temperatures. The elimination is accomplished in two ways: (1) Drying winds continue to evaporate moisture from aerial parts when, because of the low ground temperatures, it cannot be replaced by the movement of sap. This factor is believed to be largely responsible for the absence of forests from many sections where the relative humidity in winter is low. (2) Freezing and thawing uproots some perennials. Red clover is not a success in most of South Dakota largely because it winter-kills in this manner.

**(c) The Daily Ranges in Temperature.** The greatest daily ranges occur in the winter season when cyclonic storms are most strongly marked. Daily ranges of more than 50° normally occur in all months at

[12]The mean maxima and the mean minima were computed from the monthly minima for 1909-13: (Annual Summary for South Dakota, U. S. Weather Bureau, 1910-14, pp. 7, 8). The extreme maxima and the extreme minima are the highest and lowest temperatures recorded at the several stations during the period between the date of their establishment and 1909, (Bull. W., U. S. Weather Bureau, Summaries for Sections 33 and 34, 1912).

several stations in the state. Ranges of more tha n66° occurred widely in January, 1913; but in January, 1914, the greatest local range was 56°. In March, 1913, several localities had daily ranges of more than 70°, while in 1912 the greatest local range in March was 55°. Daily ranges of less than 20° are rare.

**Table 9.—Local ranges—1913**[13]

| | Maximum range for any station | Average maximum diurnal range (all stations) | Mean daily range by months (aver. of 10 stations) |
|---|---|---|---|
| Jan. | 71° | 50° | 26° |
| Feb. | 57 | 45 | 25 |
| March | 78 | 60 | 23 |
| April | 54 | 40 | 24 |
| May | 56 | 42 | 22 |
| June | 51 | 40 | 24 |
| July | 56 | 45 | 26 |
| August | 56 | 48 | 27 |
| Sept. | 55 | 48 | 28 |
| October | 58 | 48 | 28 |
| November | 55 | 48 | 25 |
| December | 55 | 40 | 24 |
| Mean | 58 | 46 | 26— |

The mean daily range for the month does not clearly show the influence of the passage of cyclonic storms; in fact the higher means occur in July-November, inclusive, when cyclonic storms are least prominent. These months are the warmer of the drier months of the year. Warmth and aridity both favor large ranges of temperature. The differences between these daily means (average 26°) and the maximum ranges (averaging 58° and 46°) shown in columns 3, 1 and 2, Table 9, are largely the result of the passage of such storms.

**(f) Diurnal Variability of Temperature.** The maxima of consecutive days frequently differ by more than 25° and not rarely by 30°, and the minima by slightly larger figures. Such sharp changes from day to day result from the passage of cyclonic storms.

The great daily range and the sharp marked diurnal variability are of much geographic importance. Rapid changes of temperature are active factors in the disruption of rock. They also are withstood with difficulty especially by new-comers such as new-born animals. The normal range of more than 25° between night minima and day maxima generally means that the nights are cool enough for restful sleeping.

Unseasonable killing frosts are associated with the great daily range of temperature.

**(g) The Length of the Growing Season.** The interval between the

[13]From Monthly reports for District 6, The Missouri Valley, U. S. Weather Bureau, 1913. The mean temperatures are approximate averages.

last killing frost in the spring and the first in the autumn —the crop-growing-season—averages nearly 130 days. For the northern half of the state it is nearer 120 days and for the south-eastern quarter it is 140 days. The northern border has the shortest season (115 days) and the lower Missouri valley the longest (150 days.)[14] The frost-free period around the base of the Black Hills, and on the slopes of some of the buttes where there is good air drainage is a week or two longer than the average for the state.

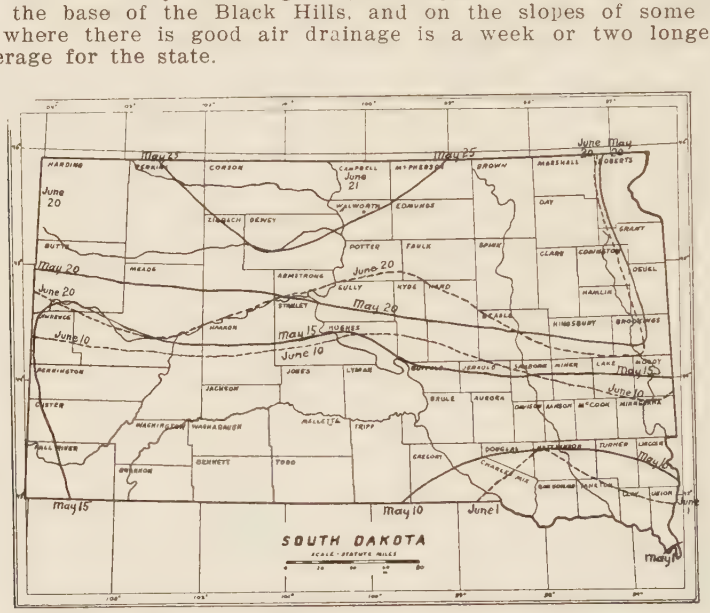


Fig. 20. Date of the average (———) and the last recorded (.....) killing frosts in the spring. From U. S. W. B.

Figures 20 and 21[15] show the dates of last killing frosts in spring and first killing frosts in autumn. The full lines indicate the average dates and the broken lines the latest recorded killing frosts in the spring and the earliest in the autumn. The interval between these latter dates is for the south-eastern section about 98 days and for the north-central, about 70 days. At the higher elevations (above 4500 feet) in the Black Hills, killing frosts have been recorded in every month of the year. Both the average and the minimum growing seasons in the eastern tier of counties of the northeastern corner of the state are nearly a week longer than in the counties adjacent to the west, far causes which are not evident.

Periods of several days with unseasonably high temperatures followed by a killing frost in May, except in the foothills, unfortunately for fruit growing, are frequent. The cultivated plum crop, for example, was largely destroyed in the southeastern counties three times in the past ten years (1904-1913.)

### (5) The Length of Day

The longest day for central South Dakota has 15½ hours of daylight, the shortest a little less than 9. From April 28 to August 17 each day

[14]The Average Length of the Crop-Growing Season, Days. Day, P. C.: Frost Data of the U. S., Bull. V, U. S. Weather Bureau, Chart 5, 1911.

[15]Day, P. C.: Frost Lines in the U. S., Bull. V, U. S. Weather Bureau, Charts 1 and 3, 2 and 4, 1911.

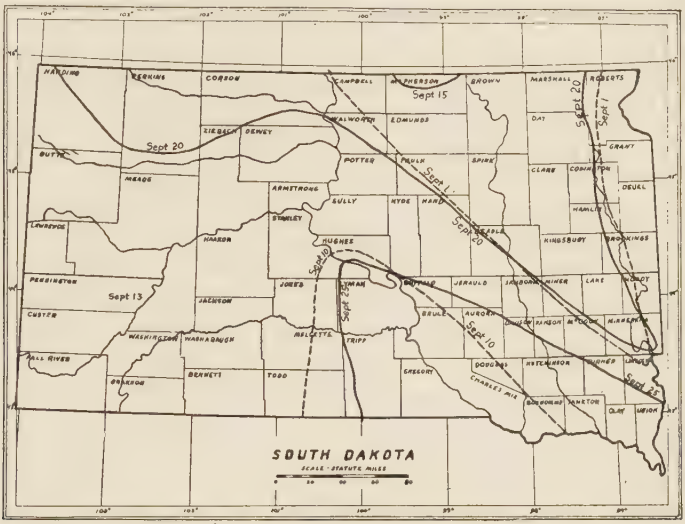


Fig. 21. The agerage earliest (———) and the earliest recorded (.....) killing frost in the fall. From Bull. V., U. S. W. B.

has more than 14 hours of daylight; and from May 20 to July 20 more than 15 hours of sunlight, and from 3 to 4 hours of twilight. The length of the day during the growing season helps to compensate for the short frostless season, since other conditions being comparable, crops mature more rapidly in latitudes having long summer days than in lower latitudes.

### (6) Humidity

The following table[16] shows the mean relative humidity at certain morning and evening hours during the growing season. The humidity for 8 P. M. during the growing season is low, 39 per cent to 57 per cent, with an average of about 47 per cent.[17] In the afternoon it doubtless frequently is under 40 per cent, as the daily maxima usually are at least 10 degrees higher than the 8 P. M. temperature.

The average annual humidity of the northeastern part of the state is about 70 per cent; of the southwestern quarter of the state 60 per cent, and of the remainder about 65 per cent.

**Table 10. Mean Relative Humidity for Morning and Evening Hours During the Growing Season**

| | | Apr. | May | June | July | Aug. | Sept. | Year |
|---|---|---|---|---|---|---|---|---|
| Huron ..... | 8 A. M. | 80 | 78 | 82 | 82 | 84 | 82 | 82 |
| | 8 P. M. | 52 | 51 | 57 | 52 | 52 | 51 | 61 |
| Yankton ..... | 8 A. M | 79 | 80 | 80 | 80 | 84 | 84 | 80 |
| Pierre ..... | 8 A. M. | 74 | 73 | 75 | 73 | 75 | 72 | 75 |
| | 8 P. M. | 57 | 49 | 48 | 44 | 44 | 44 | 55 |
| Rapid City .... | 8 A. M. | 71 | 71 | 71 | 67 | 65 | 63 | 70 |
| | 8 P. M. | 51 | 49 | 51 | 43 | 39 | 42 | 54 |
| Valentine, Neb. | 6 A. M. | 77 | 83 | 78 | 78 | 80 | 76 | 79 |
| | 6 P. M. | 49 | 49 | 52 | 47 | 48 | 46 | 56 |

[16]Compiled from the "Summaries of Climatological Data for the United States," Sections 33, 34, and 35, Bull. W., U. S. Weather Bureau, 1912.
[17]Illinois has an average normal humidity of 66 per cent for this hour.

### 7. Evaporation

Because of low relative humidity, high summer temperatures, and persistent wind, the rate of evaporation is high. Experiments have shown that in most parts of the state, evaporation from a water surface would amount to about 40 inches annually. In the northeast corner, however, it would be only 30 inches, and in the southwest corner over 50 inches.[18]

The rate of evaporation is important, for the amount of water that plants need for their development varies directly with evaporation. The character of the native vegetation is in no small degree a response to the ratio between the supply of moisture and loss by evaporation.

The rate of evaporation has much to do with what is known as sensible temperatures. The difference between the temperature as felt by human beings (sensible temperature) and the temperature as shown by the thermometer often is great. Dry air at 100° may cause less discomfort than very moist air at 80°. Sunstroke is rare in South Dakota, partly because the low relative humidity promotes evaporation from the skin and keeps the body from becoming too warm.

The very low temperatures recorded occasionally in winter are less uncomfortable than are much higher temperatures in humid regions. Most people do not feel so cold on a bright calm morning in Dakota when the thermometer registers —40° (the lowest temperatures are usually associated with calm, clear weather) as they do on windy days in a damp region when the temperature is a few degrees above zero.

### (8) Cloudiness

South Dakota is known as "the Sunshine State," not because it surpasses in this respect other states, especially those in the southwest, but because of the contrast between South Dakota and the Eastern States and northern European countries from whence most of the persons not born in South Dakota came.

At Huron[19] during the winter months there is 62 per cent of the total possible 100 per cent of sunshine; during the spring 64 per cent; during the summer 68 per cent, and during the fall 60 per cent. The year as a whole averages 63 per cent of the possible 100 per cent. The mean annual hours of sunshine for South Dakota approximates 2750 hours.

The per cent of clear days in the year for 1908-13 averaged 46; of partly cloudy days 30, and of cloudy days 24.[20]

The impression is current in the state that cloudy days in South Dakota are less numerous than cloudy days in the more humid states. The Weather Bureau does not take observations in the density of the clouds. A day when most of the sky is clouded is recorded as cloudy. However the effect upon air and soil temperatures and upon life, especially upon the activity of animals and of plant growth, varies widely with the density of the cloudy canopy. South Dakota has few "leaden days" in a year.

### 9. Precipitation

**(a) Annual.** The average annual precipitation in South Dakota is approximately 20 inches; in the eastern half about 22.3; in the western half about 17 inches. (Fig. 22.) In the former 83 per cent, and in the latter 81 per cent, usually is received between March 1 and September 30.[21] (Fig. 23.) The amount of rainfall decreases toward the west and

[18]Salisbury, Barrows & Tower: Elements of Geography, Map of Mean Annual Evaporation on p. 87, (New York, 1912).

[19]Climatology of the U. S., Bull. Q., U. S. Weather Bureau, p. 498.

[20]U. S. Weather Bureau: The Annual Summaries for South Dakota, 1908-1913.

[21]"The Summaries of Climatological Data by Sections," Sections 33 and 34, Bull. W., U. S. Weather Bureau, 1912.

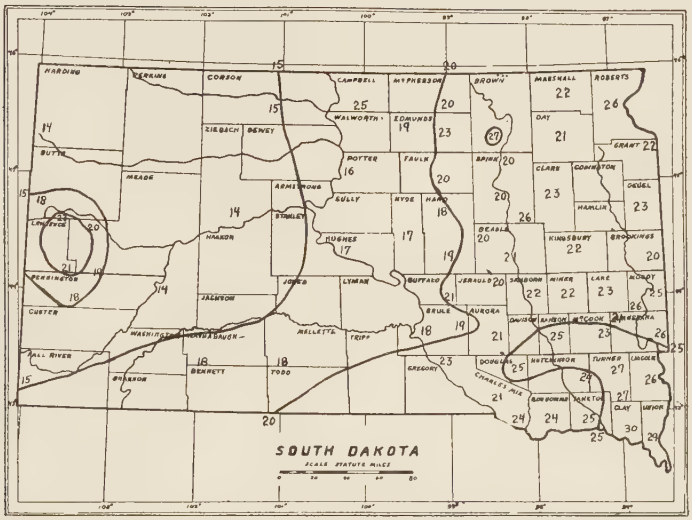


Fig. 22. Map showing the average annual rainfall in inches.

north. Because of the increased altitude, the central portions of the Black Hills receive more precipitation, especially snow, than do the surrounding plains.

**(b) The Sources of the Moisture.** The Rocky Mountains force the precipitation of much of the moisture which the westerlies carry from the Pacific Ocean, so that little or none of it is dropped over South Dakota. Because winds from the north are warmed as they come into lower latitudes, they are drying winds. Moisture from the Atlantic Ocean is largely prevented from reaching South Dakota by the fact that the prevailing winds are westerly, while the occasional easterly winds do not come from the coast. Therefore the Gulf of Mexico is the great source of moisture for South Dakota, as for most of the Mississippi basin.[22] The moisture-bearing winds are drawn to Dakota by the low pressures which accompany the passage of a cyclonic storm across the northern border of the United States. It is doubtful if moisture often is carried directly from the Gulf to South Dakota. The winds associated with cyclones move in a spiral direction and air which was moving northward when it left the Gulf would form an east or even northeast wind before it reached the latitude of Dakota. The rapidity of the passage of normal lows is an even stronger reason for this doubt. It is not until the lows have crossed the Rockies that they strongly attract air from the Gulf. In 24 hours after crossing the mountains, the center of the low usually will have crossed the Dakotas. Since the distance from the Gulf to central South Dakota is some 1300 miles, a velocity of 55 miles an hour would have to be maintained for 24 hours in order to have the moisture carried directly to South Dakota.[23] The moisture en route to South Dakota may be precipitated and re-evaporated once, a few, or perhaps a

[22]Stockman, Wm. B.: "Periodic Variation of Rainfall in the Arid Region," Bull. N., U. S. Weather Bureau, p. 7, 1905.

[23]Though southeast winds occasionally continue for two or three days, because of the spiral nature of air movement in cyclones it is altogether likely that even such persistent winds bear no moisture directly from the Gulf.

score of times before South Dakota is reached. It is obvious that each precipitation greatly increases the likelihood that some share will not reach Dakota, but will return to the Gulf in a river, be appropriated by a plant or animal, enter the underground circulation or when evaporated, be carried away from South Dakota by contrary winds. This is proved by the gradual decrease in rainfall with increasing distance from the Gulf.

**Table 10a. Daily Normal Precipitation—Huron**

| Day | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .02 | .01 | .03 | .06 | .11 | .10 | .14 | .10 | .05 | .03 | .04 | .02 |
| 2 | .02 | .01 | .03 | .06 | .11 | .10 | .13 | .11 | .06 | .03 | .04 | .02 |
| 3 | .02 | .02 | .03 | .06 | .10 | .11 | .12 | .12 | .07 | .03 | .04 | .02 |
| 4 | .02 | .02 | .02 | .06 | .10 | .11 | .12 | .12 | .07 | .02 | .04 | .02 |
| 5 | .02 | .02 | .02 | .06 | .10 | .11 | .11 | .13 | .06 | .02 | .04 | .02 |
| 6 | .02 | .02 | .02 | .07 | .10 | .11 | .11 | .12 | .07 | .02 | .04 | .02 |
| 7 | .02 | .02 | .02 | .08 | .09 | .11 | .10 | .11 | .08 | .02 | .05 | .02 |
| 8 | .02 | .02 | .02 | .09 | .09 | .10 | .09 | .12 | .09 | .02 | .05 | .02 |
| 9 | .02 | .02 | .02 | .09 | .08 | .11 | .09 | .12 | .09 | .02 | .05 | .02 |
| 10 | .02 | .02 | .02 | .09 | .08 | .12 | .09 | .11 | .09 | .02 | .06 | .02 |
| 11 | .02 | .02 | .02 | .09 | .08 | .12 | .08 | .11 | .09 | .02 | .05 | .02 |
| 12 | .02 | .02 | .02 | .09 | .09 | .13 | .08 | .10 | .08 | .01 | .05 | .02 |
| 13 | .02 | .02 | .02 | .09 | .10 | .14 | .08 | .09 | .07 | .01 | .05 | .02 |
| 14 | .02 | .01 | .02 | .10 | .09 | .14 | .08 | .10 | .07 | .01 | .05 | .02 |
| 15 | .02 | .01 | .02 | .10 | .10 | .14 | .08 | .09 | .07 | .01 | .05 | .02 |
| 16 | .02 | .01 | .03 | .10 | .11 | .14 | .09 | .10 | .06 | .01 | .06 | .02 |
| 17 | .02 | .01 | .03 | .10 | .11 | .15 | .09 | .09 | .05 | .01 | .06 | .02 |
| 18 | .02 | .01 | .03 | .09 | .11 | .15 | .09 | .09 | .04 | .01 | .05 | .02 |
| 19 | .02 | .01 | .03 | .08 | .11 | .15 | .10 | .08 | .04 | .01 | .05 | .02 |
| 20 | .02 | .01 | .03 | .09 | .11 | .14 | .08 | .08 | .04 | .01 | .04 | .02 |
| 21 | .01 | .01 | .03 | .09 | .10 | .13 | .09 | .07 | .03 | .02 | .04 | .02 |
| 22 | .01 | .01 | .03 | .09 | .09 | .13 | .09 | .07 | .03 | .02 | .05 | .02 |
| 23 | .01 | .01 | .04 | .09 | .09 | .13 | .09 | .06 | .03 | .02 | .04 | .02 |
| 14 | .01 | .01 | .04 | .09 | .10 | .13 | .09 | .05 | .03 | .02 | .04 | .02 |
| 25 | .01 | .02 | .04 | .10 | .09 | .13 | .08 | .04 | .04 | .02 | .04 | .02 |
| 26 | .01 | .02 | .05 | .10 | .08 | .13 | .08 | .04 | .04 | .02 | .04 | .02 |
| 27 | .01 | .02 | .05 | .10 | .08 | .13 | .09 | .05 | .04 | .03 | .03 | .02 |
| 28 | .01 | .03 | .05 | .11 | .08 | .13 | .09 | .05 | .04 | .03 | .03 | .02 |
| 29 | .01 | ... | .06 | .12 | .08 | .13 | .09 | .04 | .04 | .03 | .03 | .02 |
| 30 | .01 | ... | .06 | .12 | .08 | .13 | .09 | .04 | .04 | .03 | .03 | .02 |
| 31 | .01 | ... | .06 | ... | .09 | .13 | .10 | .04 | ... | ... | .03 | .02 |
| | .51 | .44 | .99 | 2.65 | 2.92 | 3.78 | 2.94 | 2.64 | 1.69 | 1.34 | .58 | .62 |

**Table 11. Daily Normal Precipitation—Rapid City, 1888-1906**

| Day | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .01 | .02 | .02 | .05 | .10 | .13 | .10 | .09 | .04 | .03 | .02 | .02 |
| 2 | .01 | .02 | .02 | .05 | .10 | .13 | .10 | .09 | .04 | .03 | .02 | .02 |
| 3 | .01 | .02 | .02 | .05 | .10 | .13 | .09 | .09 | .05 | .03 | .02 | .02 |
| 4 | .01 | .02 | .02 | .05 | .10 | .14 | .09 | .09 | .05 | .03 | .02 | .02 |
| 5 | .01 | .02 | .02 | .05 | .10 | .14 | .09 | .09 | .05 | .03 | .02 | .02 |
| 6 | .01 | .02 | .02 | .05 | .10 | .13 | .08 | .09 | .05 | .03 | .02 | .02 |
| 7 | .02 | .02 | .02 | .06 | .09 | .13 | .08 | .09 | .06 | .04 | .02 | .02 |
| 8 | .02 | .02 | .02 | .06 | .09 | .12 | .08 | .09 | .06 | .04 | .02 | .02 |
| 9 | .02 | .02 | .02 | .07 | .08 | .12 | .08 | .09 | .06 | .05 | .02 | .02 |
| 10 | .02 | .02 | .02 | .07 | .08 | .12 | .08 | .09 | .06 | .05 | .02 | .02 |
| 11 | .02 | .02 | .02 | .07 | .08 | .12 | .08 | .08 | .06 | .05 | .02 | .02 |
| 12 | .02 | .02 | .02 | .08 | .08 | .12 | .08 | .08 | .06 | .05 | .01 | .02 |
| 13 | .02 | .01 | .03 | .09 | .08 | .12 | .08 | .07 | .05 | .05 | .01 | .02 |
| 14 | .01 | .01 | .03 | .09 | .08 | .12 | .08 | .07 | .05 | .05 | .01 | .02 |
| 15 | .01 | .01 | .03 | .09 | .08 | .12 | .08 | .07 | .05 | .05 | .01 | .02 |
| 16 | .01 | .01 | .03 | .09 | .09 | .13 | .08 | .07 | .04 | .05 | .01 | .01 |
| 17 | .01 | .01 | .03 | .09 | .10 | .13 | .08 | .07 | .04 | .05 | .01 | .02 |
| 18 | .01 | .01 | .03 | .09 | .10 | .13 | .08 | .07 | .03 | .05 | .01 | .01 |
| 19 | .01 | .01 | .03 | .09 | .10 | .13 | .08 | .07 | .03 | .04 | .01 | .01 |
| 20 | .01 | .01 | .03 | .09 | .10 | .12 | .08 | .07 | .03 | .03 | .01 | .01 |
| 21 | .01 | .01 | .04 | .09 | .10 | .11 | .08 | .06 | .03 | .03 | .01 | .01 |
| 22 | .01 | .01 | .04 | .09 | .10 | .11 | .08 | .06 | .03 | .03 | .01 | .01 |
| 23 | .01 | .02 | .04 | .08 | .09 | .11 | .08 | .05 | .03 | .03 | .01 | .01 |
| 24 | .01 | .02 | .05 | .08 | .09 | .11 | .08 | .04 | .03 | .03 | .01 | .01 |
| 25 | .01 | .02 | .05 | .08 | .09 | .11 | .08 | ... | .03 | .03 | .01 | .01 |
| 26 | .02 | .02 | .05 | .08 | .09 | .11 | .08 | ... | .03 | .02 | .02 | .01 |
| 27 | .02 | .02 | .06 | .08 | .09 | .10 | .08 | ... | .03 | .02 | .02 | .01 |
| 28 | .02 | .02 | .06 | .09 | .10 | .10 | .08 | ... | .03 | .02 | .02 | .01 |
| 29 | .02 | ... | .06 | .10 | .10 | .10 | .08 | ... | .03 | .02 | .02 | .01 |
| 30 | .02 | ... | .06 | .10 | .11 | .10 | .08 | ... | .03 | .02 | .02 | .01 |
| 31 | .02 | ... | .06 | ... | .12 | ... | .08 | .04 | ... | ... | ... | .01 |
| Mean | .44 | .46 | 1.05 | 2.30 | 2.91 | 3.59 | 2.55 | 2.11 | 1.26 | 1.10 | .46 | .46 |

Fig. 23. Average Monthly precipitation at nine well distributed stations.

**(c) Monthly Precipitation.** The monthly distribution of precipitation is favorable to agriculture. The months of heaviest rain are May, June and July. The least precipitation is received during January and February (Fig. 23.) The following table[24] gives the mean monthly precipation at Huron, Pierre and Rapid City, representing the eastern central and western sections of the state.

Fig. 24. The average rainfall of the eastern half of South Dakota in the five growing months as compared with other states.

**Table 12. The Normal Monthly Precipitation**

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Huron | | | | | | | | | | | | | |
| 1881-06 | .51 | .44 | .99 | 2.65 | 2.92 | 3.78 | 2.94 | 2.64 | 1.69 | 1.34 | .58 | .62 | 21.1 |
| Pierre | | | | | | | | | | | | | |
| 1891-06 | .46 | .44 | 1.33 | 1.98 | 2.13 | 3.08 | 2.35 | 2.01 | 1.11 | .81 | .43 | .50 | 16.6 |
| Rapid City | | | | | | | | | | | | | |
| 1888-06 | .44 | .46 | 1.05 | 2.30 | 2.91 | 3.59 | 2.55 | 2.11 | 1.26 | 1.10 | .46 | .46 | 18.7 |

Fig. 25. The average annual rainfall at Yankton, Spearfish and Pierre, from 1892 to 1911.

[24]Bigelow, F. H. The Daily Normal Temperature and the Daily Normal Precipitation of the U. S., Bull. R., U. S. Weather Bureau, 1908.

[4]Wild fruits and berries were very abundant in 1864, the year of the severe drouth and grasshopper ravages, and greatly helped the settlers tide over the winter (Foster, J. S.: Outlines of History of Dakota, p. 23, Yankton, 1870).

**(d) Number of Rainy Days.** In eastern South Dakota there are about 71 rainy days[25] a year at each weather bureau station. At Pierre and Rapid City there are about 92 such days. The average of all the stations in western South Dakota, however, gives nearly the same figures as in eastern South Dakota,—73 days a year.

**(e) Variability in the Amount of Precipitation.** The annual rainfall varies very greatly in South Dakota as illustrated by Fig. 25 which shows the fluctuation in total amount at Yankton and Pierre during two decades.[26]

The average for the entire state in some years has been less than two-thirds the normal amount, as in 1894 and 1910. At some stations it has been less than half the normal amount for that locality, as at Sisseton in 1888, Pierre, Kimball and Yankton in 1894, Ipswich in 1898, Huron in 1910, and Orman in 1911. At a few stations the rainfall has been in one year fifty per cent. larger than normal (Vermilion 1909), while amounts 30% in excess of normal are frequent and widespread.

The variation from year to year as regards seasonal distribution is much greater than the fluctuation in the annual precipitation, and has much more geographic significance. The month of June, for example, at stations where the normal precipitation is more than 3.5 inches, may receive less than .5 inches in some years, as at Hermosa in 1910, Highmore in 1911 (.09 in. in 1911, 3.55 in. normal), Academy in 1912, (.32 in. 1912, 3.88 in. normal), Hopewell, Stanley Co. in 1913 (.22 in. in 1913 4.44 in. normal). Monthly deficiencies of but slightly less than 3 inches are widespread and frequent for the months of the growing season. The results are often disastrous. The almost complete failure of crops in Stanley county in 1912 is an example. Precipitation from 2-4 inches in excess if the normal for a given month also is common during the growing season.

The variation in rainfall during the growing season influences the crop yields very greatly. Not infrequently twice the normal precipitation is received during one month when the next may receive less than half the normal. Consequently fair or good yields of such crops as are in the stage to benefit by the abundant rainfall of the wet month may be obtained, while crops which are in their critical stage of growth during the dry month may yield little. Thus in 1895 the rye crop was very poor but the wheat crop was good. In 1910, though the potato and hay yields were low, wheat yielded faily well in many sections since rainfall at opportune times for wheat in many parts of the wheat growing area in the state. In 1911 though the yields of most crops were low, that of corn was normal. The variation in the precipitation during the growing season and its effects on agricultural prosperity is one of the strongest possible arguments for diversified farming.

**Table 13. Rainfall Per Month (Average of Huron, Yankton, Pierre and Rapid City)[27]**

| | Apr. | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|
| 1909 ..... | .85 | 4.16 | 3.84 | 2.54 | 2.36 | 2.24 |
| 1910 ..... | .71 | 1.67 | 1.70 | 3.04 | 1.84 | 2.21 |
| 1911 ..... | 1.90 | 1.66 | 1.38 | 2.08 | 2.77 | 1.99 |
| 1912 ..... | 2.34 | 2.74 | 1.05 | 4.60 | 2.84 | 1.76 |
| 1913 ..... | 2.11 | 4.10 | 2.16 | 3.20 | 2.10 | 1.86 |

[25]A rainy day is, according to the definition of the U. S. Weather Bureau, one having .01 or more inches of precipitation.

[26]The data from which Figs. 25 were constructed were obtained from the "Summaries of Climatological Data of the U. S. by Sections," 33 and 34, and "Annual Summaries" for 1909, 1910, 1911, U. S. Weather Bureau. Fig. — is copied from Bull. W., U. S. Weather Bureau.

[27]Data from Ann. Summaries for 1909-13, U. S. Weather Bureau, p. 9.

The average yields of the chief crops for the state as a whole fluctuate widely from year to year. While wheat yielded but 6.6 bu. per acre in 1894, it yielded 12 bu. in 1895, 8 bu. in 1897, 19 bu. in 1900, 12.8 bu. in 1910, 4 bu. in 1911, and 14.2 bu. in 1912. Similarly the yield of oats has ranged from 7.4 to 39 bu. per acre; rye from 4.5 to 20.2 bu. per acre; corn 4.2 to 33.5, potatoes 23 to 105, and hay from .55 to 1.46 tons per acre. Fluctuations of far greater amounts have taken place within small areas. Nearly complete failures in one section may be counter-balanced in such averages by excellent yields in other localities.

**Table 14. Crop Yields in Various Years in Bushels Per Acre Average for South Dakota[28]**

| | 1894 | 1910 | 1911 | 1912 | Aver. 1880-1909 |
|---|---|---|---|---|---|
| Wheat | 6.6 | 12.8 | 4.0 | 14.2 | 11.4 |
| Oats | 7.6 | 2.3 | 7.4 | 33.8 | 27.0 |
| Corn | 4.2 | 25.0 | 22.0 | 30.6 | 22.0 |
| Potatoes | 23.0 | 44.0 | 72.0 | 105.0 | 79.0 |
| Hay (tons) | 0.94 | 0.8 | 0.55 | 1.46 | 1.3 |

**(f) Snowfall.** The average annual snowfall for the state is about 24 inches, but the variations from year to year and from place to place are very great. For example, 247.2 inches have been recorded in one winter (1910) at Greenmount, Lawrence County, in the Black Hills at an elevation of 6430 feet and in 1880-81 more than 100 inches were recorded at many points in the eastern half of the state. In some other winters there has been only a slight snowfall in most sections. The snow usually does not remain long on the ground. Sleighing is infrequent. Grazing may be continued throughout all but the exceptional winters. When such winters have come (as in 1886-87, 1887-8, 1897-8,) there has been great loss of livestock. The loss in 1886-87 is said to have been more than 50% of the cattle on the range in the Black Hills region.[29] Of recent years, however, stockmen have not relied entirely upon grazing and the losses have been far less.

**(g) Hail.** There is an average of about 30 days per year with thunderstorms.[30] The summer rains generally are of the thunderstorm or conventional type, often giving heavy downpours in a few hours, but rarely more than two inches fall within 24 hours. Hail sometimes accompanies the thunderstorms in sufficient quantities to be destructive, but the losses due to it in South Dakota are far less than in some of the states to the south.

### 10. Variability of the Weather

The weather in South Dakota is variable, as is the weather of most sections of northern United States. The variability is produced chiefly by the procession of those cyclonic storms—high pressure and low pressure areas—which cross the continent in the general latitude of South Dakota. The centers of many pass over or but a short distance to the north or south of the state. The lows usually are accompanied by cloudiness and precipitation; the highs by lower temperatures and clearer skies. A given cyclone or anti-cyclone usually passes in three days, the center crossing the state in one day. A rapid succession of changes in the weather therefore is typical for all parts of the state. The fluctuations in temperature from day to day frequently are more than 30°. The effects of such variation has been commented upon.

[28]The Year Book of the Department of Agriculture. 1894-1912.
[29]Baldwin, G. P.: The Black Hills, p. 59, (Chicago, 1904).
[30]Bull. Q., U. S. Weather Bureau, plate 28.

### 11. Supposed Changes of Climate

Many old settlers claim or claimed before 1910 that the climate is changing.[31] Droughts undoubtedly are less disastrous now than formerly, but the cause is probably to be found in other reasons than changes of climate There is a better adjustment of crops to the area: —crops which are better able to withstand the conditions, and varieties which are better acclimated have replaced the ill adapted crops and varieties introduced by the early settlers. (2) The population is not so near the margin of want as formerly. With diversified farming and stock raising, a reserve supply of food and stock, and probably a bank account, a single dry year, or even two or three in succession, cannot cause as much suffering as similar droughts would have caused in pioneer days. The climatic influence of the artesian waters brought to the surface is doubtless negligible, and is more than offset by the drainage of many lakebeds.

The U. S. Weather Bureau and others have made extended studies of the changes in climate reputed to follow settlement and have been unsuccessful in establishing that there have been any such changes. Professor Henry of the U. S. Weather Bureau has recently summarized and discussed this general topic in an illuminating manner.[32] His conclusions are:

"It is apparent on inspection that the annual precipitation progresses from year to year in an exceedingly irregular manner and without, so far as discoverable, any approach to uniformity in time or space. One year of heavy rain may be succeeded by a second, third or even fourth year of abundant precipitation, and again a single year of heavy rain may be followed immediately by a year of light rain."

"The probability that the rainfall will be normal is very small. The distribution mostly to be expected is that which approaches closely to or falls slightly below the normal.[33]

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[31]Finley, Lieut. J. P.: Certain Climatic Features of the Two Dakotas, pp. 20-25, (Washington, 1893); Andreas, A. T.: Historical Atlas of Dakota, p. 87, (Chicago, 1884).

[32]Henry, Alfred J.: Secular Variation of Precipitation in the United States, Bull. Am. Geog. Soc. XLVI, Mar., 1914, pp. 192-201.

[33]Loc. cit., pp. 198, 201.

# CHAPTER SIX

## THE BIO-GEOGRAPHY

Introduction, p. 68; The Bio-Geographic Districts, p. 77; The Ecological Formations, p. 79; Steppe, p. 80; Prairie, p. 95; Meadow, p. 97; Woodland, p. 98; and Aquatic, p. 103.

### I. INTRODUCTION

Although the native flora and fauna represent but a small portion of the life which in any area ultimately may be put to the use of civilized man, and may include few species of conspicuous economic significance, their study is well worth while for several reasons. (1) It makes practicable a comparison even of widely separated areas in respect to climate, ground-water and soil. (2) It greatly extends our knowledge of geographic conditions, making possible, for example, an intelligent selection of useful varieties of plants and animals which may be introduced with probable success. (3) The flora in many cases is an indication of the agricultural possibilities of an area. (4) Vegetation and animals affect run-off, erosion, and soil. (5) The native biota has vastly influenced human activities, and its study therefore is a prerequisite to a full understanding of the human geography of any region. These points will be taken up after a brief discussion of some requirements of species and some differences between the original and possible future biotas.

Each species has many and in most cases complex requirements such as proper amounts of (1) moisture, including water vapor as well as liquid water, (2) heat, including requisite periods when the temperatures are above definite minima, for example 32°. (3) light, including sunshine, (4) food, inorganic as well as organic, (5) appropriate anchorage for sessil forms, (6) proper sites in which to rear their young, (7) not too powerful rivals or enemies, (8) effective means of dissemination. Moreover, various plants are fertilized by but few and some of them by highly specialized insects. The range of such plants cannot extend much beyond that of such insects unless they are propagated vegetatively.

An environment may be favorable in almost all respects to various species which are not found there, but if only one of the numerous requirements is unfulfilled, that species is barred. In a region where the climate is as variable as in South Dakota, an area perhaps may be favorable for a given species during most years, but the exceptional drouth or the occasional unseasonable frost may keep the species out. Species which possess means of prompt re-introduction may soon be re-established after local extermination. The great significance of means of dispersal is indicated by the fact that the species which are most widely distributed over the globe are those which are distributed through the air by the winds, as willows, birches, poplars, bacteria, diatoms and fungi, or those that are able to fly, as most insects, birds, and bats, while the next most widespread are those disseminated through the agency of civilized man. Deficiency in means of dispersal tends to retard greatly the spread and to restrict the ranges of many interdependent groups, as examples of which are tree-squirrels and nut-bearing trees, fruit-bearing birds and bats and certain trees and shrubs. Herbs whose seeds are armed with hooks depend largely upon wide-ranging mammals for their spread. Numerous animals are carried by others while in egg, larval, or adult stages. Examples are certain molluscs which attach themselves to the gills of fish, and all parasites, many of which cause sickness and produce "diseases."

There are numerous illustrations of the success of species which have crossed the barrier of sea, mountain or other unfavorable tract,

and have become established in South Dakota. The English sparrow, **(Passer domesticus)** Norwegian rat, **(Epimystr rattus)** and house mouse **(Mus m. musculus)** among the vertebrates, the house fly **(Muscidae)** tent caterpillar and potato beetle **(Lepintotarsa decemlineata)** among the insects, the Russian thistle, **(Salola)** sweet-clover **(Melelotus)** and pigweed **(Chenpodium album)** among the plants are a few examples.

Many additional species may prosper if conditions are improved but slightly in one or more particulars. Thus slight improvement in (1) planting, (2) cultivation, (3) supplying water at critical times and places, might enable some species not now represented to establish themselves. Wells have increased in many respects the utility of areas naturally deficient in drinking water. The marvelous results of irrigation are well known. (4) the virtual lengthening of the season by affording protection in the early stages of growth by means of hot-beds for various vegetables. (5) protection from enemies. The animals of prey have been nearly exterminated over large portions of the state. (6) The elimination of competitors. The bison, antelope, and mustangs were rivals of cattle, sheep and horses, and were of necessity nearly exterminated before the latter became common. Without the breaking up of the sod and the consequent destruction of the native vegetation of the area affected, the raising of nearly all crops would be impossible in South Dakota.

For these reasons and perhaps others, the flora and fauna which will occupy this area when it is finally put to its maximum use by highly civilized man will be far more abundant, profitable, and diverse than that which originally prevailed, and it probably will be richer in species, although many native species will be exterminated over large areas. This enrichment will take place along at least the following lines. (1) Similar regions the world over will yield species which will be introduced and put to the use of man. (2) Some of the plants now useless doubtless will become useful, with the advance of civilization. Two decades ago, for example, it was not anticipated that the guayule shrub would give to desert lands where it grows a value of as much as $20 per acre which it now does because it became profitable to extract the rubber which it was found to contain. (3) The improvement of native stocks by hybridization and selection has accomplished much and has great possibilities. (4) The acclimation of certain forms not at first successfully raised is practicable.[1] (5) A thorough adjustment of the biota to the geographic conditions, especially climate and soil, would enormously increase the productivity of the area. (6) Improved methods of transportation and preservation and increased local markets may make it profitable to put all portions of the area to more effective use. (7) Drainage or irrigation of areas susceptible thereto very greatly increases their productivity.

Because large areas in South Dakota were primitively, or still are very uninviting, does not prove that they will not support a large population in the future. The area irrigated by the Bellefourche project is located mainly on gumbo, and but a short time ago was exceedingly unattractive. Now it is worth more than $100 per acre. Areas, miles in extent, which in the range days could not permanently support a single steer because of the occasional lack of drinking water and winter food, can now, with the help of wells, a small amount of hay, and shelter, support scores per square mile. Great confidence is expressed by those best entitled to an opinion, including Prof. N. E. Hansen of the U. S. Experiment Station at Brookings, that within a decade or two much of the sod of millions of acres of South Dakota will be sprinkled with luxuriant plants of certain Siberian and hybrid strains of alfalfa, and

[1]For an excellent discussion of these four methods see Hendrick, U. P.: "Multiplicity of Crops as a Means of Increasing the Future Food Supply," Science, Oct. 30, 1914, pp. 611-620.

thus the productivity of certain lands increased from nearly nil to exceed that of the present best grazing lands of the state.

Although the original biota thus differs widely from the biota likely to prevail under conditions of high civilization and dense population, its study is distinctly valuable as a preliminary step in the determination of the geographic conditions of the area.

Bio-geography extends our knowledge of geographic conditions in various ways: Some of them are listed below:

1. Climatic data of nearly all sorts may be greatly supplemented.
2. The general geographic conditions are indicated by the ecological aspects.
3. Slight variations in these general conditions are marked by corresponding changes in vegetation and animals.
4. Many differences in the various climatic factors are revealed.
5. Differences in soils are indicated in many places.
6. The nature of the subsoil and the depth of the soil is revealed at many points.
7. The depth to the water table is shown in many places.
8. Many slight differences of slope or elevation are made conspicuous.
9. The likelihood that an area will be flooded, or, in case of areas normally submerged, will be exposed, is shown in many places.
10. The value of certain areas for the production of certain crops is suggested.
11. The rate of erosion of slopes is suggested.
12. The directions or points of the compass are indicated roughly by various plants and animals.
13. The physiographic or even geologic history may be illuminated.

These points demand some further discussion.

1. Climatic data of nearly all sorts are greatly supplemented:—

In mid-latitudes, especially in continental interiors, there may be great climatic variation from year to year and decade to decade. Records of a moderately satisfactory sort cover but a short period for most of the Weather Bureau stations in South Dakota. At but four stations do they cover twenty-five years, and at but thirty-four, most of which are in the eastern third of the state, more than fifteen years. Therefore the local climatic records permit only an imperfect knowledge of the climate of the state. By using the dominant species as an index, comparison may be made with corresponding areas, such as parts of Nebraska and Kansas which have records that cover a much greater interval.

The dominant native plants and animals of any region have been selected not by the climate of a brief period, a decade or even a century, but by that of centuries. The study of the native biota therefore makes possible in many places a very great extension of knowledge concerning the climate.

2. The general geographic conditions are indicated in most places by the ecological aspects of the biota and therefore furnish indices for comparison of areas:—Plants closely similar in appearance (ecological aspect) have evolved in various plant families under the influence of similar conditions. Certain spurges in the drier parts of South Africa very closely resemble American cacti. Arborescent representatives of most families are found in the tropical rain forests; even the grasses and horsetails are represented there by forms which might be classed as arborescent. The plants of grasslands are chiefly herbaceous. Plants resembling the sage are found in all steppes, and the pincushion, pillow and carpet types of growth are developed at high elevations or in high latitudes by members of nearly all plant families which are represented here.

If two environments, for example southern Siberia and western South Dakota, present the same ecological aspects and types, and perhaps many representatives of identical genera and species, the chances are that a species from one environment will thrive in the other, if introduced. Various strains of Siberian alfalfa have been introduced into South Dakota, and some give great promise. The introduction of forms from regions quite unrelated ecologically is on the other hand less likely to be successful. The resulting loss may be much greater than the direct loss because of the discouragement to the introduction of new varieties which one failure usually produces.

(3 and 4.) Minor climatic differences are shown in many places by minor differences in the biota:—

The effects of decreased evaporation or increased precipitation are shown by differences in the ecology of different areas occupied by a general ecological type, as between the southern and northern parts of a prairie, steppe or woodland. Plants such as the twinflower or bunch berry, which are restricted to the moister or more mesophytic sides of canyons at low elevations in the southern part of South Dakota are much more widespread in the northern part, and at higher elevations in the Black Hills.

The persistence and velocity of the wind at various exposed points is shown by the stunted (krumholtz) character of the woody growth, and the direction from which the prevailing winds blow is shown in many cases by the lopsided shape of trees.

As an illustration of the indication of minor temperature differences the following case showing a conspicuous influence of a season somewhat longer than the average and free from killing frosts may be cited. In Harding County, in the northwestern corner of the state, wild plum thickets are numerous and extensive on portions of the slopes of the forested buttes, while they are rare elsewhere in that part of the state. The local Weather Bureau stations, which are all in the valleys, record a frostless season usually too short for even wild plums. Their abundance on the sides of the buttes indicates clearly a longer frostless season at that elevation. An observing horticulturist has located in this belt an apple orchard which has yielded well for several years. Similar belts are indicated by the native vegetation in the Black Hills and elsewhere.

5. Differences in soils are indicated by the material brought up by burrowing animals and in many places by different types of vegetation:—

Some species of plants grow on a great variety of soils; many others thrive best on certain types, while still others are highly characteristic of a single type. Soil conditions therefore may be recognized commonly by the predominance of different species of plants, and often may be differentiated when seen even from a distance by the shades of color that dominant species give to such areas. A better illustration of this scarcely can be found than at the northeastern corner of the Black Hills where, from Bear Butte, more than a dozen types of soils, weathered from numerous rock formations which outcrop thereabouts, are distinguishable by the aid of their vegetal covering. On the heavy clay, chenopods and wheat grass give a dark green or brown color. The sandy soil is clothed with tall, stiff, usually straw-colored sand grass, or the reddish-yellow bunch grass. Sandy-loam areas have the greater light-colored cover of needle grass which waves conspicuously in the breeze. The clay-loam and silt have a velvet-like buffalo-grama grass carpet. Gravelly areas are blotched with the low shrubs of the lead plant where the matrix is loam; where it is silt, the color is lightened with some species of sage, a genus dominant on many areas of silty soil. In the foothills where sandstones outcrop, there are scattered pines; where shale outcrops in that locality, there are no trees. The contact between the limestone and

the redbeds is made conspicuous at a distance of many miles, because pines occupy the limestone to its very margin in most places.

6. The nature of the subsoil and the depth of the mantle rock are revealed at many points:—

Materials brought up by burrowing animals are perhaps commonly sufficient indications of the nature of the subsoil.

The thickness of the soil and of the mantle rock is shown clearly in the distribution or character of various species of plants and burrowing animals in areas where firm rock is near the surface, as in many parts of the Black Hills and the quartzite and granite areas in the southeastern and northeastern parts of the state.

7. The depth to the water-table is shown in places where this depth is not great. The establishment at such points, of the general water-

Fig. 26. Part of one of the lakes of the East Coteau or Lake Region. A lake near Webster having more trees than the average.—Courtesy of the C. M. & St. P. R. R. Co.

level makes possible an approximation of the depth to permanent water in wide areas where the depth is too great to be reached by most local vegetation.

The accessibility of underground water is strikingly shown by the distribution of certain kinds of trees. (Fig. 26, 27, 28), the groves of willow, ash, elm, and several other kinds occupying portions of the river bottoms, the little thickets or single trees near hillside springs, all indicate clearly available ground water.

Various sedges and rushes grow only in areas where seepage takes place, at least part of the time. Lignite, which is relatively impervious, causes seepage in many places where it outcrops on slopes. Vegetation in such zones is fairly conspicuous, and has been used often in locating "coal diggings."

It appears that prairie-dog towns are located only where the water table is within reach of these able burrowers. The location of more

Fig. 27. A view in the Red Valley which surrounds the Black Hills.

Fig. 28. An alfalfa field in the Belle Fourche Valley, near Newell. The trees are along the river.

than 100 towns examined in Harding, Perkins, Fall River, Stanley, and other counties seems to bear out this statement.[2]

8. Slight differences of slope or elevation are made conspicuous by differences in the vegetal covering in many places:—

In swampy areas very slight differences in elevation commonly are accentuated by distinct differences in vegetation, and in many places the depth of water in lakes and marshes is suggested clearly in the distribution of reeds, sedges, water buttercups, pond lilies and other plants. On slight slopes the depressions and direction of slope are in many places conspicuously indicated by differences in the vegetation.

9. The likelihood that an area will be flooded is shown in many places:—

Certain species notably of grasses and terrestrial animals are unable to resist even occasional floods, and are lacking in areas where they occur, while certain plants, such as cottonwood and some willows, become established at the margin of flooded areas and, dead or alive, may long indicate the flood. The biota of areas normally submerged but occasionally exposed differs somewhat strikingly in many places from the inhabiting areas permanently submerged. Bodies of water which never freeze to the bottom are inhabited by a richer biota than are those that freeze occasionally.

10. The value of certain areas for crops is suggested in many places:—

"Land which bears a pure short-grass cover was found to be supplied with water in the surface foot or two of soil only, and usually even to that depth for but a brief period during spring and early summer. Land with a uniform cover of tall grasses was found to be supplied with water to a much greater depth and to offer conditions favorable for plant growth during a much longer season. As a connecting link between these two conditions a short grass cover which supports a scattered growth of taller plants was found to indicate intermediate conditions as regards water supply.

"The area of greatest agricultural value one year with another are those marked by the presence of the wire-grass vegetation. Of almost equal value are the areas characterized by those phases of the grama-buffalo-grass vegetation which are distinguished by the presence of a considerable quantity of Psoralea or of wire-grass. Bunch grass land is best for crops during especially dry years, but is relatively the least productive during favorable years. Typical short-grass land (grama-buffalo-grass association) produces more than any other type during wet years, but is first to fail in time of drought.[3]

were in South Dakota, they made possible the establishment of permanent agricultural settlements before they would have been successful without this assistance.

8. Where fur-bearing mammals are numerous, skins, a natural commodity which usually has high value, is available for export.

The "Fur Trade" was at its height in Dakota long before permanext agricultural settlement commenced, and therefore it influenced the settlement slightly. However, the trapping of fur-bearing animals has been carried on incidentally by many persons, and has contributed not

[2]The one small town which might at first seem to contradict this generalization is located on the table near the north end of the West Short Pine Hills in Harding County. Since permanent springs are numerous at the base of the Miocene formation where it outcrops on the margins of this table, some 30-50 feet below the level of the town, it is probable that water may be obtained at a corresponding level beneath the dog town. The selecting of the site for this town might lend support to those who advocate that animals possess the power of reason.

[3]Shantz, H. L.: Bulletin No. 201, Summary, 1911, U. S. Department of Agriculture, Bureau of Plant Industry.

11. The rate of erosion of slopes is suggested:—

In most places bare slopes indicate rather rapid erosion, and slopes covered with vegetation, notably trees, indicate much less rapid erosion. In the sandhills, dunes which have remained relatively stationary for a considerable interval have in some cases groves on their north-facing slopes.

12. The directions are roughly indicated by certain plants and animals:—

The leaves of the compass plant (silphium) usually have their edges in a north-south direction; several kinds of lichens and mosses are found chiefly on the north sides of trees and stones; the vegetation on a steep north-facing slope is somewhat markedly different in most places from that on a steep south-facing slope; several burrowing animals, (ants, badgers, prairie-dog), either in the distribution of the material brought up or in the driection of the burrow, give a rough approximation as to directions. Woodpeckers' holes generally are on the northeastern or eastern side of a limb or tree. The entrance to covered nests of such birds as the meadowlark, ovenbird and marsh wren in most cases is on the east.

13. The physiographic and even some points in the geologic history may be illuminated by the distribution of species, especially their presence or absence in areas now favorable to them. Bluffs along the valleys become covered with vegetation soon after the stream ceases to erode at their base The age of trees on such slopes, as also of those in ravines and on terraces and alluvial fans, suggest the age of these physiographic features. The presence in the Black Hills of numerous boreal species such as the white spruce (**Picea alba**) and northern marmot (**Marmota dacota**) suggests that during the geological past (the glacial period) such species were widespread in this latitude. With the change of climate some have been stranded in the Black Hills.

In addition to increasing geographical knowledge in the various ways mentioned above, the biota affects runoff, erosion, soil, and evaporation.

The percentage of precipitation which runs off is affected by the biota. Burrows of worms, insects, amphibians and mammals, footprints of heavy animals, and roots, especially decayed ones, facilitate the entrance of water into the soil. Matted and coarse vegetation especially retard run-off.

Erosion is retarded by a vegetable covering. The disintegration of rock by temperature changes is also retarded by vegetation. The decay of rock materials by chemical means is facilitated by the secretions and remains of plants and animals. Animals in general accelerate erosion, especially on steep slopes.

Soil is mixed and extended by burrowing animals, which also increase aeration and oxidation. All animals and plants contribute organic matter to the soil. The roots of plants are potent factors in rupturing rock. By retarding the washing away of soil, however formed, plants are powerful agents in the accumulation of a deep soil.

Water which otherwise would run off is conserved in soil clothed with vegetation, and given up gradually by evaporation, which process lowers the temperature and increases the relative and absolute humidity; therefore evaporation of soil moisture normally is increased by the vegetal covering.

**Bio-geography and Human Geography.** Human activities in an area are determined largely by the geographic conditions which prevail there. The bio-geography reflects but slightly geographic location, area and mineral resources, though climate, soil, topography, and water conditions influence and are influenced by biota.

The native biota is a geographic factor of great human significance. The following illustrations applicable to South Dakota indicate a few of its manifold influences.

1. A grassy area facilitates grazing and agriculture as woods have to be cleared, in most cases laboriously, before extensive tillage or pasturage is possible.

2. Where the soil is tough, laborious breaking necessarily precedes agriculture.

4. Plains which are periodically covered by dry grass permit of widespread prairie fires and necessitate foresight, care, and cooperation on the part of the settlers.

5. Where but little of the area is wooded, as in South Dakota, the importation of wood is necessary and wood is valued highly. The small area of woodland in South Dakota was less of a handicap than it might otherwise have been because, (a) lumber served as "return freight" in cars which were used for the export of wheat, cattle and other bulky commodities. In portions of the state which do not export large quantities of such produce, the cost of imported lumber is much greater; (b) barbed wire became fairly cheap before it was extensively needed in South Dakota for fencing; (c) ash groves widely distributed along the valleys and cedar thickets in portions of the western part of the state furnished a large share of the posts required. The character of the upland (nearly level and heavily sodded) made the hauling of posts and firewood less expensive than it might otherwise have been; (d) lumber mills were erected early in the Black Hills, the forested buttes in Harding County and along the lower Missouri River, and the local demand supplied, at least for a time.

6. The type of the grassy covering has influenced greatly the grazing industry. In many portions of the earth, grazing is less profitable than in South Dakota. This is due in no small degree to the "natural hay" which is formed here under the influence of the scanty rainfall of autumn and winter. The growth of many kinds of grass ceases before there are heavy frosts, and the nutriment largely remains in the dried standing grass until the rains of the following summer.

7. Where game birds and mammals are abundant, as they long a little to the firm establishment of many pioneers and some later settlers.

9. Where animals of prey, such as wolves, coyotes, bears, pumas, horned owls, and other animals, are plentiful, as they formerly were or still are in parts of South Dakota, their numbers must be depleted before various sorts of livestock and poultry can become very profitable.

10. Where herbivorous animals of certain kinds, such as bison, prairie-dogs, rabbits, locusts, are very numerous, their reduction is an essential antecedent to success in various human activities. The same may be said of poisonous animals and plants.

11. Various animals, especially birds and insects, have been valuable allies of man in his struggle against undesirable animals and plants ("weeds"). Predatory insects, of which there are many sorts, including various spiders, hymenoptera, and ground beetles, are powerful enemies of numerous plant-eating insects. Various insects of which the milkweed bug and monarch caterpillar are examples feed solely or chiefly upon certain weeds.

12. Wild fruits, berries, seeds, nuts, and roots contribute to the food supply of many persons, and in some instances were of great significance to pioneers[4] and others.

## II. THE BIO-GEOGRAPHIC DISTRICTS.

Based on the biota, South Dakota may be divided into three districts (Fig. 29) which reflect differences of (a) climate, (b) topography, (c) soil, and (d) routes of immigration into the area. The districts are (1) the Eastern Third of the state (largely Prairie), (2) the Great Plains, (3) the Black Hills. Representative or characteristic parts of these districts differ somewhat strikingly. However, sections of stream valleys in the Great Plains are transitional between that district and the first (the prairies), while the forested buttes, escarpments and foothills are transitional between the dry grassy plains (the steppe) and the forested mountainous Black Hills.

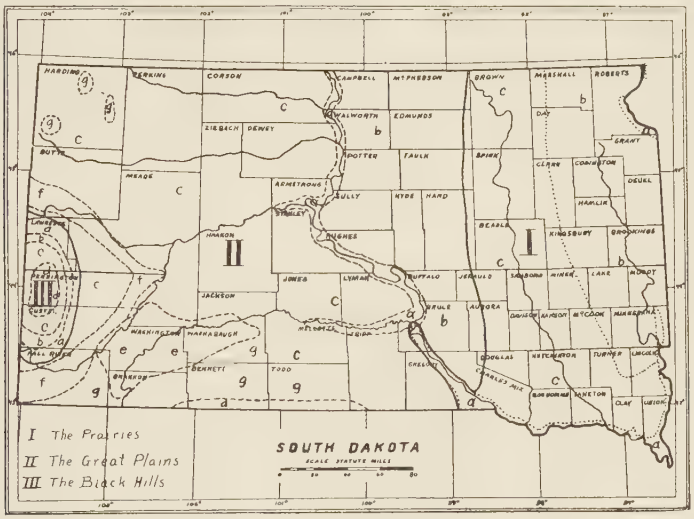


Fig. 29. Biogeographic Districts. Ia.—The Valleys of the Lower Missouri, Sioux and Minnesota Rivers. Ib.—The East Coteau. Ic.—The Dakota Valley. IIa.—The Upper Missouri Valley. IIb.—The West Coteau. IIc—The Dry Plains. IId.—The Sand Hills. IIe.—The Badlands. IIf.—Gumbo Areas (other small areas not shown.) IIg.—Buttes and Escapments. IIIa.—Foothills. IIIb.—Red Valley. IIIc.—The Limestone Plaeau. IIId.—The Park Area.

(1) **The Eastern Third** of the state is largely prairie, but along most valleys there are meadows or somewhat dense groves of deciduous trees. This part of the state is fairly well favored in respect to rainfall, having an average of about 26 inches or nearly 50 per cent more than the average for the rest of the state, the higher parts of the Black Hills excepted. More than three-quarters of the precipitation falls during the six warmer months (April 1-Oct. 1). The warmest as well as the coldest parts of the state are within this district and the average annual and daily ranges are as great as in any other part of the state or even greater.

This is the least rugged large part of the state, as most of it has a topography characteristic of a recently glaciated plain. The soil is chiefly clay-loam.

Many "eastern" plants, birds and other animals are found in this district, as it is contiguous with the prairies and savannahs of Iowa

and Minnesota and somewhat similar to them. Most genera and a majority of the species of this district are most abundant (have their center of dispersal), to the southeast, outside the state. As an illustration of the predominance of eastern species, it may be mentioned that more than 95 per cent of the birds and flowers commonly seen are somewhat common east of the 90th meridian. Nearly as large a percentage of the trees are of indubitable southeastern affinities.

This district may be divided into (a) the broad river valleys of the southern, southeastern, and northeastern margins, (b) the eastern coteau, and (c) the Dakota valley. The topography of these subdivisions has been discussed (p. 50).

(a) Various species of trees, including the soft maple (**Acer saccharinum**), Kentucky coffee tree (**Gymnocladus dioica**), black walnut (**Juglans nigra**), and the red mulberry (**Morus ruba**) are native to South Dakota only in the lower Missouri and Sioux valleys, and the sugar maple (**Acer saccharum**) is represented in the state only in the shaded ravines about Lakes Bigstone and Traverse near the headwaters of the Little Minnesota River. Numerous smaller plants characteristic of the eastern moist woods are limited to these valleys, and many typically eastern kinds, notably several species of warblers and vireos, are seen, chiefly as migrants, only in this extreme eastern part of the state. The fox squirrel (**Sciurus rufiventer**) also is found only in this subdistrict.

(b) The eastern Coteau originally had far fewer trees than subdivision (a), but at present there are numerous groves which were planted soon after the region was settled. A majority of the 600 square miles of wood-lots recorded by the census of 1900 from South Dakota are within this section. The presence of many marshes and lakes has made this an attractive region for various, largely eastern, species of aquatic plants and water birds, and with the growth of the artificial groves, various eastern birds of the woods have become common in most parts of this region.

(c) The Dakota Valley originally had more woodland than the East Coteau, but fewer planted groves have become established, and although most of the sky-line is made by trees, not nearly all farms have woodlots. Thriving groves are especially rare in the northern and western parts of this wide valley, since the precipitation decreases in those directions.

(2) **The Great Plains** bio-geographic district includes most of the state west of the Dakota Valley, except the Black Hills. This district is mostly a steppe, chiefly occupied by short grasses, low herbs and terrestrial animals. Trees are few, being nearly restricted to a fringe of cottonwoods and boxelder along the few fairly permanent streams. This district is notably more arid than the preceding, the rainfall being less regular as well as less abundant. The topography is mostly the result of fluvial and pluvial erosion, and is moderately rough in many parts. The soils are more varied, there being large areas of each of several types. Many eastern species of plants and animals, especially those living in the valleys, here reach the western limit of their range, and a number of western species, especially among those of the uplands, reach here their eastern limit. Several conspicuous forms appear to have spread eastward or westwawrd, or both, from the Great Plains; however, a number of species have entered this district from the southwest.

Several subdivisions of this district are readily recognizable. (a) The postglacial part of the Missouri flood-plain (above Charles Mix County) and the lower sections of the flood-plains of its chief tributaries have many eastern species which are associated with the trees dependent on the relatively high water-table; (b) the Western Coteau,

transitional in regard to many species, between the typical dry plains and the Dakota Valley; (c) the central part occupying much of Stanley, Meade Perkins and other counties; (d) the sandhills of the southern border are similar to those of Nebraska, and contain representatives of many southern species not found elsewhere in the state. (They are treated separately in the chapter on physiography, and the section on the ecology of the steppe); (e) the badlands in the southwestern quarter, especially along the upper part of the White river, have many species which here are near or at the northeastern limit of their range; (f) the gumbo areas (Fig. 29) bordering on the Black Hills in the valleys of the Cheyenne and Bellefourche rivers have many plants species which are characteristic of such heav clay soils; (g) the forested buttes and escarpments are intermediate or transitional areas between the grassy Great Plains and the forested Black Hills: Both coniferous and deciduous trees are important, and there are many species of plants and animals found in the Black Hills and the Rocky Mountains, as well as some distinctly eastern species.

(3) **The Black Hills District,** a bio-geographic as well as physiographic unit, is a mountainous area largely forested with conifers. Because of increased altitude, the precipitation is above the average for the state, while the average temperature and the rate of evaporation are lower, with the result that there is sufficient moisture for many species which require a good deal.

Many Rocky Mountain species reach their easternmost position in the Black Hills. A large number of eastern species appear to have followed up the east-west valleys which cross the plains to this district. When the ice-cap covered eastern South Dakota, the climate of this region was doubtless less arid than now. At various times during or shortly before or after the glacial period the unglaciated plains doubtless were more favorable to various species than they now are. A few conspicuously boreal species are found here also. The latter, of which the white spruce **(Picea Canadensis)** is a striking example, probably reached this area when the ice sheet occupied eastern South Dakota, and the climate of the portions of the plains was sufficiently cool to be congenial. Those in the Black Hills now are separated from their nearest relatives (in central Manitoba) by several hundred miles of dry plains.

As might be expected of a somewhat isolated area such as the Black Hills, a number of indigenous species are recognized ,several mammals, (a red squirrel, **Sciurus hudsonicus dakotensis),** marmot, **marmota dacota,** a wood rat, **Netoma floridana baileyi** and others), one bird (the white-winged junco, **Junco aikeni),** and several plants, belonging to various groups.

There are several bio-geographic as well as geologic, physiographic and ecological sub-divisions of this district, (1) the foothills, (2) the red valley, (3) the limestone plateau, (4) the park area on the schist. The canyons and the higher peaks also have several peculiar species.

## III. The Ecological Associations

**Variety of the native biota and bases for its classification.** In the treatment of the biology of the diversified area such as South Dakota, it is desirable to sub-divide the region into sections having many features in common. In this state there are native about 60 kinds of mammals, 300 species of birds, 24 kinds of reptiles,—snakes, lizards and turtles, 7 species of amphibians, many more than a thousand species of insects and more than 2,000 species of seed plants. In addition there are fishes, mollusks, crawfish, worms and many smaller forms. Of this vast variety of life very many are inconspicuous and not ob-

served by non-specialists, although without doubt each species has its part to play in the biologic economy of the whole. This is made the more likely when it is noted that nearly every species occupies a definite place; for example, the species of the shaded ravines are not at all the same as those of the plains.

It is therefore convenient to subdivide the state into areas occupied by different biological associations or communities of plants and animals. Communities or associations having many similarities may be grouped into what technically is known as a **formation.** The formations of South Dakota are (1) grass-covered dry plains or steppe,[5] (2) prairie, (3) woodland, (4) meadows, and (5) aquatic. The former occupies the most extensive area and the latter the least extensive. The areas occupied by these several formations are characterized by distinctive features of topography, soil, water conditions, climate, vegetation and animal life. Individual plants (with a few exceptions) are stationary, but the species moves by means of the seeds, runners or off-shoots. In the case of animals, most species and individuals are able to move about, consequently the animals are but partially confined to a given association. The coyote, for example, may be found in each community, but in some, as the stream, pond, or marsh, its presence obviously indicates a visit. In the case of animals, the areas in which they rear their young are considered to reveal the associations to which they truly belong.

## 1. THE STEPPE FORMATION OR GROUP OF COMMUNITIES.[6]

### A. As a Whole.

#### 1. Distribution.

About three-fourths of the state is covered by vegetation characterized by its patchy or scattered distribution and, in most associations, by its shortness.

The steppe group of associations has its center in the Great Plains section, occupying most of bio-geographic District II (Fig. 29), and is represented in small exposed areas on clay soil and in the western part of the eastern third of the state (District I.) The grassy tops of most of the flattish-topped buttes of the western third of the state, and many treeless portions at lower elevations in the Black Hills also are occupied by members of this formation.

### 2. GENERAL GEOGRAPHIC CONDITIONS OF THE STEPPE.

The climatic conditions of the Great Plains are severe. The rainfall is irregular in its distribution. It sometimes falls in hard show-

[6]References to literature on the steppe: The physical geography is treated in earlier chapters of this paper where additional citations are given. Little has been written on the biology of the South Dakota steppe. The author's papers on the biology of south-central South Dakota, S. D. Geol. Survey Bull. 5, pp. 61-130, 1912, and on the biology of Harding County, northwestern South Dakota, S. D. Geol. Survey Bull. 6, pp. 11-103, 1914, are chief. The birds of Stanley County are treated in The Auk, April, 1909, pp. 144-153; of Fall River Co. in the Wilson Bulletin, March, 1912, pp. 1-6, and March, 1913, pp. 38-39; of Harding County in The Auk for January, 1911, January, 1912, and July, 1913, summarized in Bull. 6; The plants of south-central S. D. in Muhlenbergia IX, 1913, pp. 45-52, of northwestern South Dakota, ibid, pp. 67-84. The only other articles are short lists of birds and plants of portions of the old Rosebud Reservation by Reagen, A. B., and Jones, Sheridan, S. D. Geol. Survey, Bull. 4, 1908.

Pound & Clements: The Phyto-Geography of Nebraska, 1900, and Pool, R. J.: A Study of the Vegetation of the Sand-hills of Nebraska, 1914, are valuable discussions of the plants of a neighboring state. Shelford, V. E.: Animal Communities in Temperate America as illustrated by the Chicago Region, 1913, although it contains no treatment of the animals of the steppe, is of great value.

ers and occasionally is accompanied by hail. Slight showers may bring the only precipitation received during long periods. Droughts of shorter (a few weeks) or longer (two or three seasons) duration are not rare. Ordinarily, about three-quarters of the total precipitation (which averages about 15 inches per year) takes place in the six growing months (April to Sept. inclusive). The rest of the year is conspicuously dry. The relative humidity of the atmosphere in the steppe is low and the rate of evaporation high. In much of the area, the possible rate of evaporation is two to five times the average rainfall.

The range of temperature is almost 150° Fahr. annually and frequently 50° daily. The seasons are irregular as to time of occurrence, and summer and winter exhibit wide extremes of temperature. Maxima of 100° F. and minima of —40° are not rare. Freezes which terminate most of the vegitative activity occasionally occur as early as mid-September and as late as May, and less severe frosts as early as the beginning of September and as late as early June.

Winds are peristent. The velocity is seldom high, but an 8-12 mile breeze is almost constant during the daytime. In the summer, such winds may be exceedingly hot and, if the air is very dry, may wither the vegetation. In the winter the winds often are very cold. When driving dry snow, high winds are peculiarly severe.

There is little protection from the heat of the sun for the plants or for non-burrowing animals, except those which can be sheltered by low shrubs, which are rarely dense, the larger herbs, and the very low cliffs ("cut banks") which are found here and there along the valleys. Dark cloudy days are infrequent. In light conditions, the steppe approaches the desert.

Most of the area is in the stage of erosion known as early maturity. Nearly all is underlain by only locally consolidated clays and sands.

### 3. THE MORE CONSPICUOUS PLANTS AND ANIMALS.[7]

(a) **Plants.** The predominant plants are the grasses,[8] the grama grass, buffalo grass, wheat grass and triple-awned grass being chief.

Plants of the Composite family occupy second place. In the summer they are more conspicuous in many places than the grasses. Nearly a third of the common species belong to this family. The most noteworthy are:[9] blazing-star, golden-rod, cone-flower, golden-aster, white aster, resin or gum-weed, nigger-head, worm-wood, sage, prairie-sage, sunflower, yarrow, prairie-pink, fleabane, and two with no common names, **Sideranthus, Actinella.**

The Legume family ranks third. It includes some of the more abundant plants of these plains, notably[10] the prairie-clover, lead-plant, Dakotah vetch, buffalo-bean, loco, lupine, and wild alfalfas.

[7]The author is under obligations to the U. S. Biological Survey for determining the varieties of numerous mammals and a few birds, to P. A. Rydberg and Aven Nelson for naming plants; to Alexander Ruthven for determining reptiles and amphibians; and to L. P. Morse, W. M. Mann and others for naming insects.

[8]Bouteloua oligostachya; Buchloe dactyloides; Agropyron tenerum. A. dasystachyum, A. Smithii. Sporobolus brevifolius.

[9]Liatris punctata; Solidago missouriensis, S. mollis, S. rigida. S. serotina; Ratibida columnaris; Chrysopsis mollis, C. hirsutissima; Aster hebecladus, A. oblongifolious; Grindelia squarrosa; Braunerla angustifolia; Ambrosia trifida; Artemisia frigida, A. aromatica; Helianthus Maximilianus; Achillea millefolium; Lygodesmia juncea; Erigeron asper, E. pumilus, E. ramosus; Sideranthus spinulosus; Actinella simplex.

[10]Petalostemon purpureus, P. oligophyllus; Amorpha canescens, Lotus americanus; Astragalus caespitosus, A. succulentus, A. canadensis, Aragallus Lambertii; Lupinus argenteus; Psoralea argophylla, P. cuspidata, P. digitata, P. tenuiflora.

Abundant Monocotyledons, other than the grasses, are wild onion and prairie lilies.[11] Diocotyledons other than the composites and legumes are numerous. There are several crucifers (mustard family), including[12] shepherd's purse, wall flower, and Lesquerella, Sophia, Arabis. Several sorts of evening primroses[13] are conspicuous because of showy flowers. Chenopods[14] are plentiful in the more clayey or more sandy areas. Three genera of scrophs or beard's tongues[15] help adorn the plains. The roses, wild flax, milkwort, false mallow, puccoon, plantain, Oreocarya, and Cogswellia are also represented abundantly.[16]

(b) **Birds.** Among birds the only permanent resident represented by many individuals is the desert horned lark.[17] Longspurs of some species are found in all seasons, the chestnut-collared and McCown's longspurs nesting here abundantly and the Lapland longspur wintering here. Two other members of the sparrow family, the lark bunting and the western vesper sparrow are very numerous. The former is quite characteristic, as is also the desert horned lark. Other prominent nesting birds are the Brewer blackbird, burrowing owl, Sennett's nighthawk, upland plover. Formerly the long-billed curlew and the prairie sharp-tailed grouse were common. Several birds nest in the groves of scattered trees along the streams (considered here under woodland), but often feed upon the steppe far from their nests. Examples are: the ferruginous, rough-legged Swanson's and sparrow hawks. The cliff and barn swallows, nesting on cliffs or about buildings, are also seen often.

(c) **Mammals.** No conspicuous species appear to be confined in its range to the steppe of South Dakota, though several varieties are. Of these the plains coyote, plains pocket-gopher, certain mice and voles may be mentioned.[18] Other mammals abundantly represented on the steppe are the[19] prairie-dog, badger, jackrabbit, large and little skunks, gray wolf, kit-fox or swift, long-tailed weasel, striped spermophile, and formerly the antelope and bison.

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[11]Allium reticulatum and A. rubrum; Leucocrinum montanum and Fritillaria atropurpurea.

[12]Capsella bursa-pastoris, Erysimum asperum, E. inconspicuum, Lesquerella lunellii, L. argentea; Sophia incisa, S. pinnata; Arabis hirsuta.

[13]Onogra albicaulis; A. Nuttallii; Onagra striogosa; Gaura coccinea; Meriolix serraluta.

[14]Chenopodium album, C. Fremontii, C. incanum, C. Watsonii, C. pratinocola, C. dacoticum; Atriplex argentea, A. canescens, A. Nuttaliii, A. Suchleyana; Suaeda erecta.

[15]Castelleja flava; Orthocarpus luteus; Pentstemon acuminatus, P. albidus, P. erianthera, P. grandiflorus.

[16]Rosa arkansana, R. Fendleri, R. Woodsii; Linum Lewisii, L. rigidum; Polygala alba; Malvastrum coccineum; Lithospermum angustifolium, L. linearifolium; Onosmodium occidentale; Plantago elongata, P. Purshii; Oreocarya glomerata, O. perenans; Cogswellia macrocarpa, C. montana.

[17]In the interest of brevity and simplicity, technical names are used here only in case the common name does not indicate the plant or animal under discussion with a definiteness sufficient for the purpose at hand. Since the American Ornithologists Union adopted distinctive names for the American birds at an early date and as these names now are familiar to all students of birds, the common names may be used here without misunderstanding. The scientific names of various widely distributed and well known animals, such as the pronghorn antelope, bison, gray wolf, striped gopher, common toad and rattle snake are given only once or twice. As most common names of plants apply to more than one species, technical names usually are necessary for precision, and therefore are used more frequently. Reference to a plant by its incomplete name implies that the species is the one enumerated in the list of conspicuous species where technical names will be found, or the one mentioned only a few lines above.

[18]Canis latrans; Thomomys clusius; Geomps (bursarius) lutescens; Peromyscus maniculatus nebrascensis, P. leucopus aridulus; Perognatlius fasciatus.

[19]Cynomys ludovicianus; Taxidea t. taxus; Lepus c. campestris; L. californicus melantois; Mephitis (Chincha) hudsonica; Spilogale interrupta; Canis mubilus; Vulpes velox; Mustela longicauda; Citellus tridecemlineatus olivaceous, C. t. tridecemlinea us; Antilocapra americana; Bison bison.

(d) **Other animals.** The most common snake is the plain bull snake, with the plains blue racer next and the prairie rattlesnake third in most places and seasons. The horned lizard is numerous in many localities. The common toad is seen frequently. The Great Plains toad is characteristic but not abundant.[20]

Invertebrates aside from the insects are unimportant in this group of associations. It appears that only three of the numerous phyla are represented, the protozoa relatively sparsely, mollusca chiefly by but one species of land snail (**Succinea grosvenorii**) and the arthropoda by a few spiders[21] and centipedes, and by numerous insects of six of the eight orders: Orthoptera (grasshoppers and locusts), Diptera (gnats, mosquitoes, flies), Lepidoptera (butterflies and moths), Coleoptera (beetles) and Hymenoptera (bees, wasps, ants Ichneumons) and Hemiptera (bugs. The locusts and grasshoppers[22] are the most conspicuous insects and most injurious.

The Hymenoptera of several families (digger wasps, ants, woolly bees)are abundant. Blow flies, bot flies (**Gastrophilus equi**) and robber flies are plentiful. Lepidoptera are few upon the steppe. The beetles are mostly ground beetles.[23] Bugs are very rare upon the steppe.

## 4. "ADAPTATIONS" OF THE LIFE OF THE STEPPE TO GEOGRAPHIC CONDITIONS.

(a) Plants. The plants display a variety of characteristics seemingly related to the environments, including:

1. The predominance of perennial grasses and herbs, the latter belonging chiefly to the higher orders.
2. Compactness of stalk or flower or both.
3. Specialization of the root system.
4. Prevalence of narrow or small leaves or thick cutin (epidermis).
5. Pollination and seed dispersal accomplished in a vast majority of the species by the wind.
6. Ability to mature quickly.
7. Time of growth not closely confined as to season.
8. Destruction of exposed parts usually does not result in the death of the plant.
9. Ability to withstand inactivity, forced by drought, for even two or three years.
10. Resistance to unseasonable warm spells and frosts
11. Marked seasonal succession depending on accumulated heat, water content of the soil, relative humidity and precipitation.
12. The predominance of yellow flowers.

(1) Although in favorable years annuals are conspicuous, herbaceous perennials are its characteristic vegetation. There are no large shrubs, and no trees. This characteristic is in contrast to woodland, desert, prairie and most mashes.

[20]The technical names of these reptiles are: Pityophis catenifer sayi, Bascanion constrictor flaviventris, Crotalus confluentus and Phrynosoma douglassi hermandesi; of the toads: Bufo americanus and B. cognatus.

[21]Mostly of the jumping (Phidippus) and running types.

[22]The genera more abundantly represented include Melanophus (M. brivittatus and others); Sparogemon (S. aequale and others); Dactylotum (D. pictum); Phlibostoma; Hippiscus; Dissosteria (D. Carolina); Brachystola (B. hagna); Nachyrhackis; Xiphidium; Opeia; Accanthus. Hadtrotettix (H. trifasciatus).

[23]Perhaps the following include the more abundantly represented genera. Argynnis; Apatelia; Basilarchia; Chrysophanus; Coelnonympha; Colias; Lycaena; Thanaos.

[24]Eleodes obsoleta, E. opaca, E. tricostata; Silpha ramosua; Harpalus eraticus and others.

The relatively firm turf which prevails in the more favorable portions of the steppe hinders the establishment of annuals, which therefore are much more conspicuous in the more arid and more sandy portions. Frequent prairie fires occur where there is a fairly close turf, for reasons already mentioned. Fires are powerful factors in preventing the spread of trees and shrubs. The large shrubs are restricted chiefly to the more arid or more rugged portions where vegetation is discontinuous in its distribution and where combustible material is separated comparatively widely. During the six or eight months in which there is little vegetative activity because of lack of sufficient heat or moisture, evaporation from all exposed living surfaces is continued by the intensely drying winds which frequently prevail on the steppe. Plants not presenting living surfaces from which extensive evaporation takes place when the water lost cannot soon be replaced, have the advantage over other species. If planted on the steppe, most of the shrubs and trees not especially resistant to loss of moisture through the bark are killed during the months of inactivity rather than during the normal summer season.

(2) Compactness of stalk is illustrated by almost all the plants. Few abundant upland species reach a height, in ordinary seasons, of much more than a foot, and exceedingly few reach three feet. The majority have most of their bulk within six inches of the soil. Genera, such as the rose, sunflower, sage and golden-rod, which have representatives in other ecological formations, are in most cases represented on the steppe by the most dwarfed species of the genus. Two striking examples of small size are the plains rose, in many cases a simple bush less than five inches tall, which bears but one flower, and the plains sunflower which in most cases is less than seven inches tall, and in dry years, especially on clay, has many individuals which are less than four inches high. The conspicuous places held in the flora by the Compositae points to compactness of flowering parts. Even the grasses (grama, buffalo, wheat and others) have the spikelets somewhat compactly arranged instead of loosely as in typically prairie and woodland species.

Compactness of growth decreases exposure to the winds. In most formations, an insufficiency of sunlight results in a diffuse and extended growth. There is no such insufficiency during the growing season in the steppe. Size in many cases is related to conditions during growth. Cultivated plants normally are larger than other individuals of the same species, which in turn are larger during moist seasons, than during dry seasons.

(3) There are many plants which have developed a shallow, wide-spreading root-system. This appears to be a response to the many slight showers, the water of which does not soak in deeply. The buffalo and grama grasses have their roots mostly confined to within a foot from the surface. In contrast to these there are such deep-rooted plants as Psoralea, a rather coarse herb, which has almost all of its finer roots at a depth greater than four feet, and in some cases penetrates hard sub-soil more than six feet, and looser materials still farther. Certain genera including the sages (Artemisia) and Gutierrizia, have both well developed lateral roots and rather deep tap-roots. Most plants which are abundant on the more impervious soils have shallower root systems than those in the looser soils. Shrubs and coarse herbs have root systems which go down to greater depths, than do those of lesser plants, probably because of their greater exposure to the winds. They need firmer anchorage and a more reliable water supply than is found near the surface. The plants showing shortage of water in enlargements of the roots are chiefly the blazing star, the Indian turnip,

**Psoralea asculenta**) and the bush-morning-glory (Ipomoea leptophylla). 'he cacti (Opuntia, Mamillaria) are the only plants which store con- iderable amounts of water above ground.

(4) Most of the plants have either small or narrow leaves, and few like the prairie-pink, Gutierrezia, and the cacti are almost leaf- ess. Abundant species with resin include the cone-flower, gum-weed, and 'scralea.[25]

Many species have thick epidermis, which in many cases is covered y numerous dry scales. The sages (Artemisia, **Eurotia lanata**) Poraleas nd Antennarias have a grayish coloration due to such scales.

These characteristics of leaves and cover clearly retard evapora- ion, and thus appear to be responses to the moisture conditions of the teppe.

5. The seeds of nearly 90 per cent of the abundant species on he steppe are distributed by the wind. The tumble-weed habit, in vhich the aerial part of the plant becomes detached from the root nd are rolled across the plains by the wind, is developed almost solely y plants of the wind-swept plains. Several species with this habit, elonging to several families, are represented abundantly in South Dakota. The chenopod family is the chief one, and is represented by he giant tumble weed. The Russian thistle, and the bug-weed. Two egumes, the Indian-turnip and the wild alfalfa, two species of the Amarathnceae, a composite and two grasses also have this habit.

Persistent surface winds, few places of lodgement such as bodies f water, very rugged areas, thickets and other places unfavorable or steppe plants, and the scarcity of other agents of dispersal all ave contributed to the predominance of species dispersed by the wind.

(6) The ability to mature quickly is possessed by most plants n this formation. The period between killing frosts in spring and fall s short, averaging about 120 days and having a minimum length of nore than a month less. The growing season is shortened usually till further by the drying weather in August and September. Few onspicuous plants require more than two months for the maturing of heir seeds, and many need even less time. This is in contrast to the ondition in most other formations.

(7) The climate of the steppe is variable. In some years the egetation is two weeks ahead of normal, and the next year it may be ar behind. Delayed rains occasionally cause a surprisingly late flower- ng. We have found flowers of the rose and even of the pasque flower ate in August, following July and August rains and a very dry spring nd early summer.

(8) The characteristic steppe plants have a wonderful resistance o prairie-fires and grazing, which may frequently destroy the aerial arts. Many typical plants such as trees and shrubs of other ecological ssociations are killed by the destruction of only a small part of the erial growth. Certain steppe species are killed, however, by too fre- uent fires (oftener than once in three years for example) or by close asturing.

(9) After a series of wet years there are many new immigrants nto the steppe. A dry year or two decimates or eliminates species vhich are only visitants to the steppe. The characteristic species seem o be almost uninjured by even prolonged drought. In the summer f 1911 for example, there were localities which for two years had

[25]Especially the case in P. digitata, P. linearifolia and P. tenuiflora.

[26]The chenopods are Cycloma artiplicifolium, Salsola pestifer and Coris- ermum hyssopifolium; the legumes, Psoralea esculenta and P. floribunda; ne amaranths, Amaranthus albus and A. graecizans; the composite, Town- endia sericea; the grasses, Panicum capillare and Schedonnardus paniculatus.

been so dry that almost no grass had grown; yet when the unusu rains of August came, the ground was green within a few days.

(10) The vegetation does not start quickly in the spring; bu if after it has started, a freeze comes, suprisingly few of the mo characteristic plants are killed. The native steppe vegetation is seldo affected noticeable by early autumn frosts. In areas less likely to ha unseasonable frosts, many species are severely injured when such fros occur.

(11) The succession of flowers in an ordinary year, is strikin There are at least five well marked periods, the prevernal, verna aestival, serotinal, and autumnal. During one period the plains a dominated by one group of flowers, and during the succeeding perio by still others. The early bloomers of the steppe include Cymopter acaulis, pasque flower, violet (**Viola nuttallii**) and prairie lily. Amo those blooming in June are the beard's tongues,[27] onions, camas (**Zyg denus intermedius**), loco, buffalo bean (**Astragalus**),[28] wild flax.[29] July niggerhead (Braunia), prairie clover, wild alfalfa (Psoralea),[30] fal mallow, stemless evening primrose (Gaura), and spurge are prominen During August, the numerous species of asters,[31] golden-rod,[32] and t fleabane (**Senicio canus**) are in their glory. The sages[33] are in fu bloom early in September.

Accompanying this progressive activity there is a shifting in floris complexion of the region. Early in the season the plants are relat mainly to eastern or mountain species, while as the season advance conditions become more severe and the active or dominant species a successively related to plants of the prairies, drier plains, and final the desert.

This succession corresponds with changes in the temperatu of the air and soil, and in the moisture content of soil and atmospher

(12) Many of the more abundant species are yellow, althou several conspicuous flowers are white, orange, or pale blue. The are few reds, deep blues, or violets. Very few are streaked or mottle In the vast majority of cases the flowers are small in size as compar with those of other plant formations, and few are particularly fragra The color probably is related to the light conditions, and the fragran to the windiness, which also doubtless affects the size of flowers.

(b) Birds. The birds of the steppe possess two or more of the f lowing characteristics:

1. Nests are necessarily built on the ground.

2. Many kinds sing while on the wing. Examples are the la bunting, longspur, Sprague's pipit, and frequently the western meado lark and horned lark.

3. The songs and calls are loud compared with those of bir of woodland or prairie. Because of climatic conditions of the stepp representatives of species in many cases are farther apart than in mo other areas. Calls and songs fulfill their chief purpose only when th are heard by other individuals of the species, and therefore need to relatively loud in the steppe.

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[27]Pentstemon acuminatus, P. albidus, P. erianthera, P. grandiflorus.

[28]Astragalus caryocarpus, A. flexuosus, A. lotiflorus, A. microlobus, Missouriensis, and A. triphyllus, in addition to those given in note 6.

[29]Linum Lewisii, L. rigidum.

[30]Mentioned in note 10. The next three plants are Malvastrum coccineu Gaura coccinea, Euphorbia marginata, E. arkansana.

[31]Aster commutatus, A. hebecladus, A. multiflorus, A. oblongifolious.

[32]Solidago nemoralis, in addition to those mentioned in note 5.

[33]Artemsia aromatica, A. cana, A. frigida, A. ludviciana.

[34]Statements made by Craig, Wallace: "North Dakota Life," Bull. A Geog. Soc. XL, pp. 401-415, 1908, have led to the erroneous generalization a few animal ecologists unfamiliar with birds that gregariousness is characteristic of steppe birds.

4. Social flocking[34] is less prominent than among the birds of e woods, water, or prairies, where not only do various species migrate large flocks, but troops wander socially about in other seasons, espeally in winter, and several abundant species nest in colonies. The ackle, crow, swift, swallows, night-herons, black-birds, marsh wrens, merous water-birds, and the bobolink and dickcissel are examples. If e cliff swallow which nests here and there in the badlands, be expted, none of the abundant birds of the steppe nest in colonies. The attered distribution of life on the steppe, noted in the preceding paraaph, is exemplified in the distribution of the nests of the steppe birds. e lark bunting and longspurs, and occasionally the Swinson's hawk grate in flocks which however, soon break up. Flocking in the nter is largely accidental. Birds gather where food is available, in eas swept by the wind or in patches of taller vegetation which are t snow-covered. Weedy fields, where seeds are abundant, often are e site of such gatherings.

5. Many have the ability to withstand strong wind. For example, ed-eaters feed during the winter in apparent comfort on wind-swept lls.

6. Females and nestlings are almost all protectively colored. This ems required by the exposure of the nesting sites.

7. Most species are highly migratory. Few individuals remain ring winter, and these are of species different from those of sumer, except in the case of the desert horned lark. Even this species grates somewhat. The aridity and the inactivity of other life come with the cold to encourage the desertion of the steppe during the nter season.

8. Most birds have the ability to withstand the intense heat of e sun. This is especially notable in the nestlings which are often dark ground.

9. The birds of the steppe of necessity must require but little inking water. Heavy dews are rare.

10. The power of acute long-range vision appears to be possessed a much larged number of birds of the steppe than by those inhabng woodlands. Clearness of atmosphere, slightness of relief over large eas, and the widely scattered distribution of life all probably have couraged the development of acute long-range vision.

(c) **Mammals.** The mammals of the steppe have all acquired two more of the following characteristics:

1. Ability to run swiftly. Examples are the antelope (32 miles hour), jackrabbit (28 miles an hour), coyote (24 miles an hour), fox or swift (20 miles an hour), and gray wolf (20 miles an hour).[35]

It is possible to run more swiftly upon dry grassy plains than rough woods or brush, in marshes or across rugged tracts. For this ason the inhabitants of such plains have come to be the fleetest nners. Long distance running was developed among some of the ger mammals, apparently because of the relative scarcity of places retreat.

2. Ability to burrow. Examples are the pocket-gophers, striped phers, badgers, prairie dogs, mice voles. About 70 per cent of the cies rear their young in burrows and nearly 50 per cent of the spes spend much of their time underground. Burrows are retreats from t, cold, wind, and some enemies, and for the prairie dog, at least some cases, furnish access to the underground water supply.

3. Many have acute long-range vision. The fleet runners all have.

[35]Velocities are those attained by the normal, healthy adult when pursued greyhounds, and are quoted from Seton, E. T.: Life Histories of Northern mals, (New York, 1909).

This appears to have been developed by the same factors mentioned i the discussion of the vision of birds.

4. A gray or tawney type of coloration which harmonizes wel with dead leaves is possessed by nearly all. The skunk, an exceptior is less in need of protective coloration than are the other mammal of the plains.

5. Ability to do without much drinking water. Water for physic logical activity and for cooling by perspiration is secured mainly fror the food eaten. Footprints of most steppe animals are seldom see in mud about water holes. This is especially true in regard to th rodents, including the jackrabbit.

6. The daily period of activity is chiefly in the early morning in the evening, and to a lesser degree at night.

Voluntary activity of almost all abundant mammals of the stepp is very limited during the heat of the summer day, when as many a may are in the shade. Activity generates heat which must be elim inated by perspiration, which in turn requires water, an article whic often is precious.

7. Ability to hibernate. The long-distance runners and the ca nivores do not hibernate, but, with the exception of the rabbits, rodent the most numerous mammals on the plains, do, and for longer period than related species in other formations. Hibernation is a response t the unfavorable conditions which prevail during the winter months.

8. The larger herbivores, the bison and antelope, migrated chief in response to irregularity of rain and snow. Wolves, which preye upon them, accompanied them in their wanderings.

9. A few of the mammals of the steppe are gregarious; the bisc and antelope congregated probably for protection from wolves an bears, and in response to the lack of numerous places of escape; bu also in winter for the heat accumulated in a closely packed herd. Prairi dogs are grouped in towns for protection against coyotes and certai hawks, and possibly by the somewhat restricted soil and ground wat conditions which they appear to require.

(d) **Reptiles.** The reptiles of which the bull-snake, rattle-snak plains garter snake, and blue-racer, and the horned lizard are chie possess a surprisingly effective coloration; hibernate for nearly half th year, or even longer; can get along without drinking water; and a of small size as compared with related forms in more humid area Although the vast majority of reptiles lay eggs, three of the five abu dant steppe reptiles (the rattler, plains garter snake, and horned-lizard bring forth their young alive. This may be in response to the "hard conditions imposed by the climate.

(e) **Insects.** Concerning the insects of the steppe, the followin points may be made:

1. The diurnal period of greatest activity is in the forenoon fro 7-11 o'clock, after the chill of the early morning is gone but befo the heat becomes oppressive. Coition is carried on chiefly between o'clock and one. During the rest of the twenty-four hours most the insects are quiescent except when disturbed.

2. Seasonal activity is limited nearly to the warmer and mo moist three or four months of the year, chiefly June, July and Au ust. There is almost complete inactivity during the colder and dri months of the year. Most species are dormant during ten or elev months of the year, when many are represented chiefly by eggs.

3. Many forms burrow or occupy mamalian burrows, in so doi having retreats from wind, heat, cold and some enemies. Steppe sp cies in many cases burrow to much greater depths than related spec of other communities.

4. There is a predominance of hoppers or fast walkers. The development of hopping as a chief mode of progression is not so much discouraged on the steppe as in several other formations by frequent collisions with tall vegetation. The habit of running is favored by bare soil and is more marked among insects of the drier than of the moister parts of the steppe, and still more among those of the desert.

5. Few species spend much time on the wing. The windiness of the steppe discourages extended flights. The occasional large flights of locusts form conspicuous exceptions to this rule.

### (B) THE BUFFALO-GRAMA GRASS OR CLIMAX STEPPE ASSOCIATION.

This is the short-grass association par excellence and in many respects is the most characteristic steppe assoriation. In the central part of the steppe region it is found on a variety of medium soils, lighter clays, silts and loams, and is the dominant association over wide stretches. As the heavier and lighter soils are altered to loams by mixture and other processes, and as the drainage is perfected and ruggedness decreased, this association is extended at the expense of the other steppe associations.

To the east of the Great Plains province, the buffalo-grama grass association is represented on the high prairies on well drained clay soil. In the more arid belt to the west it is found where the run-off is less rapid, as on the flattish tops of buttes and on terraces.

One of the two dominant grasses, the short, curly, buffalo-grass, is less tolerant of sand than is the taller grama grass, various species of which are of secondary importance in distinctly sandy areas.

The life of this association is more varied than that of other parts of the steppe. Many of the species mentioned as represented generally in the steppe are most abundant here, and in no other part of the steppe is found so large a number of species. In addition, the Triple-awned grass is abundant upon the more silty and loamy areas, and the needle grass (Stipa), and June grass (**Koeleria cristata**( on the more sandy soil. The small milkweed (**Asclepias pumila**), the pincushion cactus (**Mamillaria vivpare**), and **Parosela aurea** are rather numerous.

Nearly all the birds of the steppe nest usually or occasionally in this association. The Sprague's Pipit is here characteristic. The bison and the pronghorned antelope appear to have been at home here. The striped gopher is most abundant here, but reptiles and toads are less abundant.

### (C) THE NEEDLE GRASS OR SANDY LOAM STEPPE ASSOCIATION.

This association occupies uplands on sandy-loam soil and is characterized by the needle, devil's or spear grass and June grass just mentioned. In areas of rather uniform soil and topographic conditions these two grasses may dominate. In more sandy areas, coarse herbs of astragalus, lupines and psoraleas are very conspicuous and comparatively uniformly distributed, and sand grass occupies small areas especially on slopes. In soils having a larger percentage of silt or clay, there are patches of buffalo and grama grass. The lead-plant is in evidence in areas of coarse sand, or gravel mixed with finer materials. These herbs, and others that are represented less abundantly, have showy blue flowers. During the weeks preceding the shedding of the needles, this association is perhaps the most beautiful of those of the steppe, because of the needles which glisten and wave in the breeze and the blue flowers then conspicuous. These are set off by the yellow

[36]Astragalus mollissimus, A. adsurgens, A. canadensis; Lupinus pusillus.

and brownish flowers so widespread on the steppe. When the needles are ripe they become readily attached to clothing, long hair or wool, and by the help of several twists which develyop as the needles dry, readily work inward and often cause pain. For obvious reasons, hay containing many needles is much less desirable than common prairie hay. The mowing and grazing, especially by sheep, of areas infested with needle grass is confined preferably to the season before the seeds begin to ripen in July, or after the needles have fallen.

### (D) THE WHEAT GRASS OR CLAY STEPPE ASSOCIATION

The dominant grass or clay is the western wheat grass, sometimes popularly known as salt grass. It is widespread in areas where shales outcrop and along flood-plains. The generalized soil map (Fig. 2) shows the area of clay soils, and thus the region in which this association is most widespread. This grass has a very much larger percentage of its growth more than two inches from the soil than do the other widespread steppe grasses of fairly level areas. It also responds to an increased supply of water in a more satisfactory manner than the other abundant steppe grasses; in fact in some places and in some seasons, it attains a height of two feet. It therefore is a valuable hay crop along the flood-plains and on other areas which are flooded frequently, but upon which the water does not stand long. Because clay is relatively impervious, the percentage of absorption is slight except where the water stands for a time. Because of these geographic factors, enterprising farmers and stockmen erect wing dams and dig contour ditches in favorable places, and use flood waters to produce excellent meadows.

Although wheat grass is present in a rather pure stand in areas which are flooded frequently, in many places various other species are conspicuous. The variety of abundant plant and animal life is normally less in this than in other parts of the steppe however.

On well drained slopes on the "gumbo," the vegetation is scanty except in wet seasons, and the soil is little concealed. Among the scattered growth of grass, various chenopods[37] and the crucifer pepper-grass (Lepicium) and prickly pear cactus and the dock (**Rumex venosus**) are conspicuous in many places, as are also the Dakota vetch and the gumweed.

On the somewhat alkaline soil of many "blow-outs" and other undrained depressions, alkali grass replaces wheat grass, while the smaller prickly-pear is in many places exceedingly abundant. Two or three kinds of chenopods are often conspicuous.[38]

On valley flats the spurge, "snow-on-the-mountain" (**Euphorbia marginata, E. Arkansana**) is dominant in some seasons in many places, especially near the bluffs and in prairie-dog towns. It is perhaps the most conspicuous annual growing on the steppe. The bur-tomato (**Solanum rostratum**) is another annual which is sometimes conspicuous in similar situations, and also in deserted fields. Since valley flats receive the run-off from an extensive area, there is a sporadic accurrence of numerous species belonging to other associations, many of which, however, do not mature their seeds.

The wheat grass association is at many points contiguous to groves along the streams and to shrubby associations, especially the buck bush

[37]Atriplex canescensus, A. hastata, A. Nuttallii, A. philonitra; Chenopodium album, C. Fremontii, C. glaucum, C. dacoticum, C. subglabrum, C. pratinicola, C. Watsonii; Corispermum nitidum, Monolepsis nuttaliana, Suaeda erecta, S. depressa.

[38]This grass is Distichlis spicata; the cactus, Opuntia fragilis; the most numerous Chenopods, Atriplex canescen and Monolepes nattalliana, The purslane Talinum parviflorum sometimes is conspicuous and nearly always is characteristic of blow-outs.

and sage, and upon the areas of alluvium, with buffalo-grama or meadow grass associations.

Few birds nest in the wheat grass associations. The relative barreness of the upland areas and the frequency of flooding of the other portions are doubtless major deterrent influences. The sharp-tailed grouse, however, is more numerous in the flood-plain phase of this association than elsewhere, possibly because the taller vegetation affords more protection than the upland associations. Each prairie-dog has one or more broods of burrowing owls.

The prairie-dog is the most conspicuous mammal. In parts of this association, notably in Custer and Fall River counties, nearly every low terrace along the valleys is occupied along much of its extent by prairie-dog towns. The danger of being drowned out by the flood waters is greatly decreased by piling up around each hole much of the dirt brought up from below. Many entrances are as much as 12 or 15 inches above the general level of the "flat." This piling up is not accidental, as is shown by the repeated repairing by scraping dirt in from the periphery of the mound, and by the fact that in areas not subject to frequent flooding the detritus brought up from below is scattered widely. The long-tailed weasel and the black footed ferret, which prey upon the prairie-dog, are numerous, though not often seen. Gophers and other burrowing mammals are lacking in most of the flood-plain areas in the gumbo region, probably because of the floods.

### (E) THE BUNCH-GRASS OR DRY-SOIL STEPPE ASSOCIATION

The dominant feature of this association is the bunch grass, which attains a rather uniform height of about 15 inches. These clumps are stiff, sparingly eaten, and are conspicuous throughout the year since they are seldom covered by snow for more than a short time.

This association has two distinct phases, (1) on slopes in rugged areas, bluffs along streams and in moraines, where the soil is not clay or sand; (2) on relatively pure sand. The latter may be subdivided into (a) the more nearly level stretches and (b) the sandhills. The first phase occupies but a small total area, but a widespread, being present in each of the districts and in most of the sub-districts of the area. The second phase is most widespread in middle and western Nebraska where sand commonly heaped into dunes is dominant. The area of dunes reaches a very short distance into south-central South Dakota. This association also is present in some places along valleys where the alluvium is very sandy.

The determining geographic factors in this association appear to be a scarcity of moisture in the surface layers of the soil, and a soil which is readily penetrated by roots. In areas of sand, although the run-off is slight, there is normally but little moisture in the upper six inches or more. This is the result of the active evaporation which persists until the capillary tubes are broken. Consequently vegetation possessing only shallow root systems, as does much of that of the buffalo-grama and wheat grass associations, is barred. The vegetation of this association is characterized by the possession of deeply penetrating root systems, in many cases with prominent "tap-roots."

The Spanish bayonet or soap-weed (Fig. 7) is conspicuous, while Mentzelia and the pasque flower are numerous on the steeper slopes outside the sandhills.[39]

The bird most generally nesting in this association is the western vesper sparrow. The western field sparrow is locally numerous. Several mammals, notably the jack rabbit, coyote and badger, often rear their young in the rugged areas dominated by bunch-grass. Such areas afford

[39]Yucca glauca; Mentzelia nuda and M. decapetala; Pulsatilla hirsutissima.

partial protection by their tall vegetation as well as by their relief. The rapid run-off of the rainfall is an additional factor in their desirability as resorts of these mammals.

The sandhills[40] as seen from a distance are not inviting; they appear as a low line of monotonous yellowish hills, or, if one can look down from a divide, a complex of irregularly arranged dunes with here and there the glimmer of a pond. Only a bright yellow of a patch of freshly exposed sand, or the dark green of a marsh filled with vegetation, break the monotony.

It is only when one gets within the dune district, and sees the variety of vegetation that the reason for the reputation which sandhill districts have among botanists and picknickers, becomes evident. There is a striking contrast between the more level, dry clay plains covered with a carpet of short "buffalo" grass, and the rough sandhills with their tall clumps of bunch grass, many fruiting shrubs, and narrow valleys filled with dense thickets through which ripple clear, cold brooks. Though the sand is fairly fertile, it is likely to drift badly when cultivated. Pastures here are in ill repute, because of the tendency of their soil to blow; and although there are small meadows, the roads are so heavy that it does not pay to haul hay far. Perhaps it is the impression of irredeemable wildness that gives the sandhills part of their attractiveness.

The many differences between the adjacent grassy plains and the sandhills seem to be due almost entirely to the sand. In elevation there is no notable difference; it is not likely that there is more precipitation; it is readily apparent that the sandhills in general are no cooler.

The sand, being loose and porous, absorbs at once all rainfall, even of a heavy shower. For a short time after a rain, the evaporation is very rapid, more rapid than water can be supplied from below by capillary action. Consequently the capillary tubes become broken and evaporation stops before any considerable percentage of the recent precipitation has disappeared. The balance escapes slowly, chiefly from the leaves of the vegetation and from the many voluminous springs which supply the brooks that drain the region.

As might be expected, the air temperatures become very high during sunny days, especially in the depressions. This superheated air rises and joins the general wind which often becomes very drying. The vegetation must either be able to endure rapid evaporation or it must be able to resist drying by possessing restrictions against evaporation. Both responses are found: The bunch grass (Andropogon), roses, bush-morning-glory, sunflower, and sand thistle are examples of the former; the cacti, sand cherry, yucca and prairie-pink are conspicuous examples of the latter. A number of the characteristic plants have much longer tap roots than even closely related species of the areas of harder subsoil; a few, including the cacti, bush-morning-glory, and **Psoralea lanceolate** have organs for storage of water.

The prominent plants are perhaps the following:[41] The bunch grass is dominant; sand grass, and spear or needle grass are common, both growing here in small clumps. Grasses growing between the bunch-grasses are hair grass, grama grass, and the sand-burr. The shrubs of the sandhills are sand-cherry, choke-cherry, plum dogwood, prairie willow, lead plant, buffalo-berry, and the wild rose. Spanish bayonets are numerous.

[40]Pool, R. J.: The Vegetation of the Nebraska Sandhills, 1914, is a voluminous report. For a brief earlier account, see Visher, S. S.: The plants of the S. D. Sandhills, American Botanist, 1914.

[41]The technical names of these prominent plants are: Andropogon scoparius, Calamovilfa longilfa, Stipa Comata, Eragrostis trichodes, Bouteloua hirsuta, Cenchrus tribuloides; Prunus Besseyi, P. melanocarpa, P. americana, Cornus stolonifera, Salix humilis, Amorpha canescens, Lepargyrea argentea, Rosa woodsii, R. arkansana, R. suffulta, Yucca glauca.

The more conspicuous herbs others than grasses are perhaps[42] the nnual eriogonum, spiderwort, brome rape, Allonia, Abronia, the spurges, howy Gilia, green milkweed and three members of the aper family. egumes are numerous: Lupine, prairie clovers and the narrow-leaved 'soraleas being most numerous. The more common composites are the vormwood, the viscid aster, and **Franseria acanthicarpa.** The borders f the brooks, often quite gay with flowers, are not truly a part of the teppe.

Most of the animal life of sandy regions is associated with the springs nd streams. The areas occupied by the typical sandhill vegetation have sparse and not distinctive fauna so far as the larger animals are oncerned. Of such typical portions, the birds most abundant are the vestern vesper sparrow, lark bunting and the western meadowlark. Sandy areas within the prairie region of Sanborn County, eastern South Dakota form eastern outliers of the breeding range of the prairie sharp-ailed grouse. The mammals most frequently seen are the jack rabbit, he cottontail,[43] the plains chipmunk and the pocket gopher (Geomys utescens). Because of the relative wildness of rough, sandy areas, they orm retreats for wide ranging mammals such as wolves and coyotes. Of he reptiles, the most abundant snake is the hog-nosed adder. The yellow triped swift is plentiful in the more southern sandhills and another lizard ccurs, as does a land turtle. Several insects are abundant in sandy areas, ncluding certain tiger beetles and the ant lion.

The sandhill area along the southern margin of the state has an xceptionally varied flora and fauna. In addition to species of more general distribution, mentioned above, the following are abundant there:[44] Hall's bunch grass, on the ridges; the southern sandburr, the bush morn-ng-glory, poison ivy, and dogwood. There are a few trees, especially he hackberry, cottonwood, and elm in depressions, or on the more tationary north-facing slopes. Among the herbs, the prickly poppy, sand histle, Froelichia campestris and a fourth representative of the Caper amily, are very conspicuous in season.

### (F-H) THE LOW SHRUB GROUP OF ASSOCIATIONS

This group of associations is represented in small areas, mostly by narrow bands, in the steppe formation. The buck-bush, is a transition stage between grassland and woodland, and the sage brush between grassland and desert. Most of the area ordinarily classed as badlands belong to the buffalo-grama and the wheat grass associations. However, on the steeper slopes, the portion most distinctly "badland," almost the only vegetation consistns of various shrubs.

(F) The **buck-bush** or wolfberry, **(Symphoricarpos occidentalis)**, a shrub which as a rule is about 16 inches tall, forms patches in and adjacent to groves along valleys throughout the area. It also is found here and there on slopes, especially where soil moisture is plentiful, which more often is the case on north-facing than on other slopes. Even far from woodland, there are patches along flood-plains where the ground

[42]The herbs referred to are: Eriogonum annuum, Tradescantia occidentalis, Orobanche ludoviciana, Allionia linearis, A. Nyctagina, Abronia micrantha, Euphorbia hexagona, E. Geyeri, Croton texensis, Gilia cephaloidea. Acerates viridiflora linearis, Cleome lutea, C. serrulata; Polanisia trachysperma; Lupinus pusillus, Kuhnistera purpurea, K. villosa, K. alba, Psoralea lanceolata, P. lenuiflora; Ambrosia media, A. psilostachya, Machaeranthera sessiliflora.

[43]The technical names of other animals mentioned in this paragraph are: Sylvilagus nuttallii grangeri, Eutamias pallidus, Canus nubilus, C. latrans, C. n. nebrascensis, Heterodon nasicus, Sceloporus undulatus consobrinus, Cnemidophorus gularis, Cistudo ornata; Cincendela scutelaria, C. envigata; C. vermista.

[44]Andropogon Hallii, Cenchrus carolinianus, Ipomoea leptophylla, Rhus Rydbergii, Cornus stolonifera riparia, Celtis occidentalis. Populus Sargentii, Ulmus americana, Argemone intermedia, Carduus plattensis, Cristatella Jamesii.

water is within reach. The buck-bush patches, many of which have diameter of several rods, have where dense, little value for pasturag and almost none for fodder. They are cut by the mower with difficult nor are they killed readily by plow or fire. Wild roses are commo secondary species in these patches. The chief grasses, in most place very subordinate in importance, are blue-joint (**Andropogon furcatus**), an wild rye (**Elymus canadensis.**)

There are no large animals restricted to these patches though ther are many nests of birds. In the steppe region, the prairie sharp-taile grouse, long-billed curlew, upland plover, marsh and Swainson hawk and other large birds, as well as western meadow-larks and Brewer black birds often nest here. Cottontail rabbits and gophers (**Citellus tridecem lineatus, C. Franklini**), and the large field mice (**Microtus ochrogaster** are at home here. Spiders are especially abundant.

(G) The true sage brush (**Artemisia tridentata**) is represented ver locally in South Dakota or North Dakota on silt along the lower terrace of some of the streams of the western part of the states, notably alon the Little Missouri River, Sage Creek in Pennington County, and India Creek in Fall River County. It is somewhat more widespread in north western Nebraska. In these states it is a low shrub attaining less tha half the height prevalent in more arid regions to the west. Howeve the number of individuals per square rod in many places is greater tha farther west.

The lance-leaved sage (**Artemisia longifolia, A. filifolia**) is more wide spread and is here a taller shrub, reaching a height of two or even tw and a half feet. In the western third of the state it occupies silty so chiefly on terraces.

The vegetation between the clumps of sage in many places is dom inated by patches of buffalo grass. Upon soil which is almost bare, th curious foliatious lichen **Parmelia Mollinscula** is abundant in many places Clumps of prickly pear cactus are conspicuous.

The most conspicuous bird characteristic of the sage-brush of thi state is the sage hen, which was numerous here until a few years ag It is being exterminated rapidly.

The most notable insect is the large black and white sage-moth which is very conspicuous for a few days in July or August. The larva feed upon sage leaves.

### (H) BADLANDS

Badlands are developed in many places on clap in the Great Plains those in the south-central part of the state and in Harding County in th northwestern corner are especially extensive. Large sections of thes badland areas are comparatively barren. Still larger portions are nearl level and grass covered. (Fig. 5.) The latter are discussed under th wheat grass and buffalo-grass associations.

(a) **Conditions.** In regard to precipitation, these areas fare abou the same as does the rest of the steppe. Their average temperature i probably greater because of many slopes and the partial protection fro the wind. The whitish clay reflects the sunlight, resulting in great intensity of light at times. During other hours of the day, a give spot may be in the shade. Shade can always be found along the arroya and behind steep-sided buttes. The rapidity of erosion in badlands, an the tendency for the clay to crumble and crack, are two factors apparentl very important in controlling the vegetation. Another perhaps even mor important factor is the inability of the materials to absorb or hold wate In the White River Bad Lands there are some sandhills, and some of th nearby badland buttes are capped with sand. Erosion is evidently a rapid on such buttes as elsewhere, but a rank vegetation flourishes apparently because of the water absorbed in the sand.

(b) **Characteristic plants and animals of the badlands.** In the more igged badland areas (Fig. 12) vegetation is scanty. Such as there is, mainly shrubby and possesses long tap roots. Various shrubby com-osites are especially conspicuous, especially the rabbit bush, **Gutierreizia arothrae, G. Divaricata;** blue-aster; golden-aster; false bone-set; and veral species of sage. Other plants are the gumbo-lily; Mentzelia; Salt ish; prickly pear; grease weed; and locally, **Chenopodium watsonii.** t the foot of the buttes, two annuals, the showy spurge, and thistle-mato, frequently are found. Along the channels, the buffalo-berry forms any large thickets, and on the more shaded side of many buttes, clumps western red cedar may furnish many good fence posts.[45]

The badlands, because of their relative inaccessibility, are the home of veral carnivores. Gray wolves and coyotes are more frequently met re than elsewhere. Bobcats[46] are plentiful. The puma or mountain on was formerly not rare. A few antelope still feed on some of the lats." Bighorn sheep, and mule deer formerly were common and the ghorn may not yet be extinct in the White River Bad Lands. The ammals now most frequently seen in badlands are the striped chip-unk and gray rabbit. The chief birds are the rock wren, Say's hoebe, cliff swallow, violet green swallow, western lark sparrow, turkey zzard, and prairie falcon. Rattlesnakes are not lacking, though far om common. The horned lizards ("toads") are seen occasionally.

(c) The badland life displays several peculiarities. The plants e mainly long-lived perennials, chiefly shrubby composites, and possess werful tap and anchor roots and narrow and pubescent leaves. Such rubs offer great resistance to erosion, undercutting, and slumping. ey also are conservative, late-flowering, and present to cattle very little ible material. Nearly every species has yellow flowers. In addition these perennials, there are various annuals which thrive during wet ars on the moister alluvial flats.

The animals are grayish in color with the exception of the bats, allows and swifts. The crevices and cavelets furnish homes for the ipmunk, bat, bobcat, Say's phoebe, prairie falcon, and rock wren. The ff swallow and white-throated swift find cliffs suitable for nesting sites. veral of the larger mammals, notably the bighorn sheep and mule or ack-tailed deer, are powerful jumpers.

## II. THE PRAIRIES OR FAIRLY MOIST GRASS-COVERED PLAINS

### 1. Distribution

The eastern third of South Dakota (Fig. 29) is occupied chiefly by single association, characterized, as far as the vegetation is concerned, fairly short grasses which almost completely cover the ground, giving firm turf, and by the wide-spread absence of native trees or bunch-asses.

### 2. Conditions

The moisture conditions are less severe than upon the steppe. There more precipitation and its seasonal distribution and regularity is more

[45]The scientific names of the above badland plants are: Chrysothamnus veolens; Senecia canus; Townsendia gradiflora; Chrysopsis hirsutissima; nia glutinosa; Artemisia filifolia, A. longifolia, A. frigida; Pachylophus spitosus, P. macroglottis. P. montanus; Mentzelia decapetala, M. nuda, stricta; Atriplex Nuttallii, A. Suckleyana, A. argentea; Opuntia fragilis; cobatus vermiculatus; Euphorbia marginata; Solanum rostratum; Lepar-a (Shepherdia) argentea; Juniperus scopulorum, J. sabina.

[46]The following are the technical names of the remaining badland mam-s and reptiles mentioned: Lynx rufus, Felis concolor Antelocapra ameri-a, Ovis canadensis audoboni; Odocolleus h. hemionus, Eutamias pallidus, talus confluentus; Phrynosoma douglassii hermandesi. A common bat is otis californicus ciliobrum.

favorable. (See the discussion of Bio-geographic district I, p. ——.) In regard to temperature and windiness there are no marked differences between the two districts. The prairie has less sunshine than the steppe the relative humidity is higher, and the rate of evaporation less rapid The soil, a glacial clay-loam, is fairly uniform over wide areas.

There are two phases, distinguished, so far as the plants are concerned, chiefly by the manner of growth. On the low prairies, which receive, in addition to the normal rainfall, run-off from the high prairies and, are therefore more moist (**mesophytic**) as well as nearer to the ground-water level, there is a taller, more luxuriant, and denser growth of vegetation than upon the well-drained uplands.

### 3. DOMINANT PLANTS AND ANIMALS OF THE PRAIRIE

(a) **Plants.** The grasses are mostly turf-formers having, with a few exceptions, an average height at maturity of a foot or more, with over half of their bulk more than six inches from the sod. The dominant grasses are[47] species of Koeleria, Sporobolus, Eatonia, and Panicum, with red-top, false red-top, screw grass and blue-joint abundant in wide areas. There are several secondary species.[48] The chief herbs are[49] the prairie clovers, golden-rods, vervains, asters, blazing-stars and Indian turnips.

There are several distinct seasonal aspects in the vegetation.[50] The prevernal is characterized chiefly[51] by Peucedanum, the pasque flower and the Indian tobacco; the vernal by[52] the buffalo-bean, white anemone pentstemon, violets and many others;[53] the aestival aspect by the lead plant, vervains, pine-apple flowers, black-eyed susans,[54] and others:[55] the serotinal stage by prairie clovers and blazings-stars,[56] and certain grasses,[57] and the autuminal stage chiefly by goldenrods, asters and sun flowers.[58]

There are two shrubs, low and relatively insignificant, which are widespread, the prairie rose,[59] and the lead plant or "shoe-string.

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[47]Koeleria cristata; Sporobolus asper, S. crystandrus, S. heterolepus Eatonia obtusata; Panicum Scriberianum, P. capillare, A. argrostis alba; Po triflora; Schedonnardus paniculatus, Andropogon furcatus, A. scoparius.

[48]Agrostis hyemalis; Poa nemoralis, P. compressa, P. pratensis.

[49]Petalostemon (Kuhnistera) purpureum, P. candidum; Solidago mis sourienqis, S. rigida, S. hemoralis; Verbena stricta, V. bracteosa; Aster ser ceus, A. multiflorus, A. commutatis, Liatris punctata, L. scariosa; L. spicata P. soralea argophylla, P. esculenta.

[50]Harvey L. R.: Floral Succession in the Prairie-grass Formation of E. South Dakota Bot. Gaz. XLIV, pp. 81-108, and 277-320, 1908.

[51]Peucedanum nudicaule, P. foeniculeum; Pulsatilla patens; Antennari campestris, A. neodiocia; Draba micrantha.

[52]Speisia (Argallus) Lambertii, S. sericea; Astragalus crassicarpus, plattensis, A. hypoglottis; Anemone carolinana, A. cylindrica; Pentstemo gracilis, P. grandiflorus, P. albidus; Viola pedatifida, V. Nuttallii.

[53]Oxalis violacea, O. stricta; Lithospermum canescens, L. angustifolun Sisyrinchium angustifolum; Castilleja sessiliflora; Carex media, C. festucace Meriolix serrulata; Hedeoma hispida; Polygala alba; Vicia linearis; Senec plattensis; Onosmodium molle; Poa pratensis, P. compressa.

[54]Amorpha canescens; Verbena stricta, V. obtusata; Ratibida columnari Brauneria pallida.

[55]Koeleria cristata; Festuca octoflora, Panicum Scriberianum; Eriger ramosus; Potentilla hippiana; Delphinium carolinianum; Allonia linearis; Ace ates viridiflora linearis; Physalis heterphylla; Petalostemon purpureum, canididum.

[56]Liatris (Lacinaria) squarrosa, L. punctata, L. scariola; Carduus und latus; Hymenopappus filifolius.

[57]Bouteloa oligostachys, B. hirsuta, B. curipendula; Agropyron occidental Calamovilfa longifolia.

[58]Solidago rigida, S. rigiduscula, S. missouriensis, S. nemoralis, Ast sericeus, A. oblongifolius, A. multiflorus; Helianthus scalrerrimus, H. Me milianus, H. petiolaris; also Andropogon furcatus, A. scoparius; Sporofol brevifolius; Artemisia gnaphaloides; Kuhnia glutinosa, K. eupatoroid Nabalus asper; Dysodia papposa; Grindelia squarrosa.

[59]Rosa pratincola, R. Arkansana.

**(Amorphia canescens.)** The buck bush,[60] (p——) forms patches on some hill-sides.

(b) **Birds.** The chief birds of the prairies are the prairie horned lark, prairie chicken, western meadowlark, grasshopper sparrow, western vesper sparrow, chestnut-collared longspur, upland plover, Sennett's nighthawk, burrowing owl, and Swainson's hawk.

(c) **Mammals.** The more notable mammals are[61] the eastern spermaphile badger, skunk, jack rabbit, weasel, pocket gopher, and formerly the bison and pronghorn antelope. Meadow mice[62] are abundant, especially in grain fields. Moles are found in some of the lawns of the eastern edge of the state.

(d) **Reptiles.** There are two fairly common snakes, the bull snake, **(Pityophis catenifer sayj)** and the blue racer, **(Basconion constrictor flaviventris.)** Formerly the prairie rattler was found occasionally.

(e) **(Other animals.)** The only amphibian seen frequently in the prairie association is the common toad **(Bufo americana.)** There is a much greater variety of invertebrates than in the steppe. One land snail **(Succinea grosvenari)**, is fairly abundant.

### (4) SOME CHARACTERISTICS OF THE PRAIRIE BIOTA

The denser turf and taller vegetation and the less marked specialization of root system, as contrasted with the vegetation of the steppe, appear to be associated with the less arid conditions. Nearly a third of the species are composites, 1-5 grasses, 1-8 legumes, the remaining belong to many families. About 96% are herbs or grasses, 20% wind pollinated. Among the animals the specialization is chiefly similar to that possessed to animals of the steppe, but is not so extreme.

## III. THE MEADOW OR TALL GRASS FORMATION

(1) **Distribution.** Areas dominated by a close growth of tall grasses are found in all districts of the state, but are distinctly more numerous and extensive in the less arid sections. The flood-plains of the eastern third of the state are occupied throughout much of their extent by one of these associations; another, lives in many places in grassy ravines or draws, especially in the eastern third of the state and in the higher parts of the Black Hills, while a third occupies the low meadows bordering bodies of water.

The most obvious characteristic of this formation is a turf composed of tall grasses or of tall grasses and coarse herbs and, locally, low shrubs. Instead of a large percentage of the vegetation being found within a few inches of the ground, or in small patches or clumps, as in the case in the other grass formations of the state, the grass in this formation grows rankly to a height, commonly of more than three feet, and occasionally to nearly or quite twice that height.

(2) **Conditions.** The geographic condition seemingly favorable for this association is the proxmity of the ground water at all times.

### (3) Dominant Plants and Animals of Meadows

(a) **Plants.** Along the flood-plains the dominant plants are[63] the wild rye, panic, wheat, brome and blue-joint grasses. Coarse herbs are

[60] Symphorocarpus racemosus, S. orbiculatus, S. occidentalis.

[61] Citellus t. tridecenilineatus; Taxidea t. taxus; Mephistis hudsonica; Spilogale interrupta; Lepus c. campestris; Mustella longicauda; Geomys bursarius; Thomomys t. talpoides.

[62] Evotomys gapperi loringi; Microtus p. pennsylvanicus, M. ochrogaster; Peromyscus maniculatus.

[63] Elymus canadensis, E. striatus, E. virginicus; Panicum virgatum; Agropyron tenerum, A. violaceum; Bromus ciliatus; Andropogon furcatus.

in evidence. Examples are[64] the milkweed, showy spurge (snow-on-the-mountain), beard tongue, cinquefoil, golden-rods, and certain sunflowers. Patches of buck-bush and wild roses are common and furnish shade in which tree seedlings start.

In the moist grassy ravines or "draws" blue-joint **(Calaogrostis canadensis)** or blue-stem **(Andropogon furcatus)** is dominant, with tickle **(Agrostis hymalis)** and panic **(Panicum Scribnerianum)** grasses common. Along running water or on boggy soil the slough or cord grass **(Spartina cynosuroides)** is predominant.

The vegetation of the low meadows grades into that of the marsh. The slough grass (Spartina), wheat grass (Agropyron), in some localities incorrectly called salt grass, and blue-stem (Andropogon) are most conspicuous. Sedges (Carex, Cyperus, Scirpus) dominate in some places.

(b) **Birds.** The marsh hawk, bobolink, dickcissel, short-eared owl, and, in a certain sedge (Carex sp) the short-billed marsh wren are the chief birds nesting in meadows in this state. In the western part of the state the long-billed curlew and the western grasshopper sparrow, and in the northwestern corner the Baird's sparrow nest most frequently in the tall grass of the moist draws.

(c) **Other Animals.** These areas are so limited in extent in this state that perhaps no vertebrates are restricted to them. However, various meadow mice (Micotus, Evotomys, Perognathus) are most abundant and jack rabbits **(Lepus c. campestris)** and cotton tails **(Sylvilagus floridanus similis, S. nuttalii grangeri)** more frequently have their nests in draws than on the more exposed upland. Burrowing animals are rare in the moister portions of the meadow, doubtless because of the proximity of ground-water and the consequent likelihood of flooding.

(4) **The life and the environment.** Most plants possess roots apparently able to penetrate to the water-table. The rank growth of vegetation reflects favorable conditions. Several birds nesting in the meadows are of large size such as the marsh hawk, short-eared owl, and grouse. The rank vegetation affords protection for their nests, such as could not be found elsewhere in this region.

## IV. THE WOODLAND.

### (A) In General.

#### 1 Distribution of Wooded Areas.

Woods are found (a) along flood-plains, (b) in ravines and gulches, (c) on certain steep slopes or bluffs, (d) on the upland in the Black Hills and certain buttes.

Little of South Dakota is forested. It is estimated that there is about 2,500 square miles of national forest, of which more than 2,000 is in the Black Hills. In addition, there are some 600 square miles of planted wood-lots and wind breaks. A fairly heavy stand of timber is found in the Black Hills and in parts of the Sioux Forest Reserve in Harding County (Slim Buttes, Cave Hills and the Short Pine Hills). There also are extensive groves of large trees in the lower sections of the Missouri flood-plain. Smaller groves of smaller trees are found in the flood-plains of many other streams. Even in the Great Plains there are some trees along the permanent streams. There are some trees in many of the steeper ravines, especially those that slope north. Few tree species are native on the uplands; the pine **(Pinus scopulorum)** in the Black Hills and the burr oak **(Quercus macro-**

[64]Asclepias ovalifolia, A. speciosia, A. syriaca, A. verticellata; Euphorbia marginata, E. Preslii, Pentstemon grandiflorus; Potentilla pennsylvanica; P. anserina; Solidago rigida; Helianthus annuus.

capra) in Gregory and Tripp counties and along the lower Sioux valley being chief.

The native forest trees of the state are of two types (1) deciduous, mostly restricted to valleys, and (2) coniferous, widespread topographically, but not dominant in the valleys, except locally at high elevations in the Black Hills.

### 2 The Geographic Conditions

The general climatic conditions of the woodland areas differ only in degree from those of the general area. The temperatures are somewhat less extreme and probably average lower; the precipitation is probably not greater, though because of greater absorption, it is more effective; the interior of the woods is much less windy than the open.

Most, if not all, of the deciduous trees of the state have roots which penetrate to the level of permanent ground-water. The more hardy trees such as the green ash and the western cottonwood are celebrated for their deep tap-roots. The trees shade the ground and the lower vegetation, locally making the light and temperature conditions at least periodically very different from those prevailing in the open. The trees and under-brush check the winds, and in so doing decrease the rate of evaporation. The aborescent vegetation furnishes nesting sites for birds as well as food for many insects and other animals.

### 3 Dominant Plants and Animals.

(a) **Plants.** The chief trees are (1) the western yellow pine (**P. scopulorum**), the most important lumber tree of the Black Hills and of the forested buttes of Harding County. It is represented along Pine Ridge as far east as the 101st meridian, (2) The western red cedar (**Juniperus scopulorum**) is found sparingly on the Missouri River bluffs, and more abundantly on the buttes, especially in the badlands, and in the Black Hills. Probably hundreds of thousands of fence posts have been cut from "cedar brakes" in the western half of the state. (3) The western cottonwood (**Populus Sargentii**) is widespread along flood-plains. It has been used chiefly for fire-wood. (4) The green ash (**Fraxinus lanceolata**), forms many groves in the flood-plains of the eastern third of the state, and also about the forested buttes. It is valued for posts. (5) The boxelder (**Acer negundo**), hackberry (**Celtis occidentalis**), elm (**Ulmus americana, U. fulva**) and peach-leaved and black willows (**Salix amydaloides, S. nigra**) are fairly widespread but of much less importance than the trees mentioned above. The burr oak (**qmacrocarpa**) is of minor importance except in Gregory and Tripp counties.

The large shrubs include the wild plum (**Prunus americana,** choke-cherry (**P. melanocarpa**), June or service-berry (**Amelanchier alniforlia, A. spicata**), hawthorn (**Crataegus macrocantha, C mollis, C. Sheridana**), and in certain sections the sumac (**Rhus glabra**), black haw (**Viburnum lentago**), and the skunk-bush (**Rhus trilobata.** Among the more abundantly represented lower shrubs are the buck-bush (**Symphorocarpus racemosa, S. occidentalis**), wild rose (**Rosa woodsi, R. Fendleriana**), western poison ivy (**Rhus rydbergi**) and various wild currents and gooseberries.

The chief lianes (climbers), are the wild grape (**Vitis vulpina**), woodbine (**Parthenicissus vitacca**) and bittersweet (**Celastris scandens**).

There are many herbs. The more abundant grasses are the wild rye (Elymus), blue-joint (Andropogon) and blue grass (Poa), and others of the meadows along flood-plains, mentioned above. Other conspicuous and widespread herbs include the horse mint (**Monarda fistulosa,**

**M. mollis, M. menthaefolia**), cow parsnip (**Heracleum lanatum**), false soloman-seal (**Smilicina stellata**), carrion flower (**Smilax hispida**), twisted-stalk (**Streptipus amplexifolius**), thistles (**Carduus filipendulus, C. virginianum**), goldon-rods (**Solidago arguta, S. canadensis, S. serotina, S. pitcheri**), and violets (**Viola canadensis, V. cuculata, V. pubescens, V. scarbriuscula**). In the more deeply shaded woods, especially in ravines, numerous additional genera and species are represented.

(b) **Birds.** There is a considerable variety of bird life in the woods, including in most of the state, the western mourning dove, bob-white, hairy woodpecker, northern and Batchelder's downy and red-headed woodpeckers, common and redshafted flickers, screech owl, sparrow hawk, crow, blue jay, bronzed grackle, eastern and Arkansas king-birds, alder flycatcher, common and arctic towhees, goldfinch, rose-breasted grosbeak, black-headed grosbeak or western blue grosbeak, western chipping sparrow and western lark sparrow, white-rumped shrike, yellow warbler, yellow-breasted and long-tailed chats, warbling vireos (**V. g. gilva, V. g. swainsoni**), western house wren, catbird, brown thrasher. In the western part of the state there are several mountain birds. Those especially conspicuous are the magpie, pinon jay and Canada jay, and the western robin.

(c) **Mammals.** Formerly the white-tailed deer (**Odocoileus virginianus macrourus**), puma, and black bear were abundant in all wooded areas. The first is extinct except in the Black Hills and the Sioux Forest Reserve, while the others are to be found in the Black Hills, if anywhere in the state. The wood rabbit (**Sylvvilagus floridanus similis, S. auduboni baileyi**), a variety of cottontail, white-footed mouse (**Onychomys l. leucogaster**) and other mice, gray gopher (**Citellus Franklini**), and certain bats (**Myotis l. luciligus, Eptesicus f. fuscus, Nycteris l. borealis**), are the more numerous mammals found in all woods, but the porcupine (**Erethizon e epicanthum, E. d. dorsatum**) and chipmunk (**Eutamias m. minimus, E. pallidus**) are plentiful in the western half of the state and bob-cats (**Lynx c. canadensis, L. r. rufus**), and raccoons (**Procyon l. lotor**) are not rare. The fox squirrel (**rufiventer**) is fairly abundant in the southeastern corner of the state, and the Dakota red squirrel (**Hudsonicus dakotensis**) in the Black Hills.

(d) **Other animals.** There appear to be no snakes characteristic of South Dakota woods. The lizard known as the swift (**Sceloporus**) is seen occasionally in the southeastern quarter. Tree frogs (**Acris gryllus**) are rare in the state, but not absent. The American toad (**Bufo americanus**) is somewhat common. Seven genera of land snails[66] are recorded from the woods of the state by Wm. H. Over of the State Survey, who kindly supplied most of the data on mollusca given in this chapter.

(4) **Some Characteristics of the Life of the Woods.** Most of the plants have a deeply penetrating root system. This is probably due to the porous alluvial soil and the fact that the water table is within relatively easy reach. Trees exposed to the persistent winds develop strong anchor roots. Because of the generally low relative humidity, the leaves of most trees are small, and the bark of the trunk and limbs thick. The local conifers are extreme examples. The tree with the largest leaves (basswood, **Tilia americana**) is restricted to the more shady ravines in the most moist area, the extreme southeastern corner. Most of the shrubs and herbs also have small leaves, or other methods of retarding evaporation. Many species yield berries and

[65]Dicentra cucularia; Trilluum erectum; Arisaema triphylum, etc.

[66]In groves along streams, Pyramidula cronkhiti anthonyi, P. alternata, Vitrina alaskana, Cochleona lubrica; In ravines, Bifidaria armifera, Euconulus fulvus; in pine woods, Oreolielix cooperi, Euconulus fulvus.

rely upon animals for seed dissemination.[67] Some of the trees, notably the cottonwood, willow, ash and boxelder, which grow in the more exposed situations, depend upon the wind to carry their seed.

Most of the birds nest in trees. Many are sociable in their habits, at least in certain seasons. Several species nest in loose colonies. Most common species are highly migratory, apparently a response to the hard winters; but during the winter several species, in most cases migrants from the north, usually can be found in the woods. The western tree sparrow, long-tailed chickadee, redpoll, siskin and Bohemian waxwing, are locally common in winter. Various other characteristics of woodland birds have been mentioned or contrast in the discussion of the birds of the steppe. About one-fourth of the mammals of woods are somewhat arboreal, about one third rear their young on the ground, and about two-thirds spend most of the time on the ground, while about 40 per cent have burrows in which the young are reared. However, only about six per cent spend most of their adult lives underground.[68]

### (B) GROVES ALONG FLOOD-PLAINS

As previously noted, there are many groves in the flood-plains of the eastern third of the state, and a few smaller ones along the permanent streams even in the most arid section. Since flood-plains receive the run-off from the other wooded areas, it is natural that the other wooded flora should be more varied than in any other associations. In addition to the species mentioned as of general distribution in woodlands, there are sporadic representatives of conifers, oak, sumac, and many herbs and other species more common on bluffs and in ravines.

### (C) RAVINE AND GULCH WOODLAND

This, the most humid (mesophytic) association of the state, is represented most extensively in the valleys of the shorter tributaries of the Missouri, Sioux and Minnesota rivers, in ravines on the side of Wessington Hills in Jerauld County and the Pine Ridge in the south-central port of the state. The hackberry (**Celtis occidentalis**) and ironwood (**Ostrya virginiana**) are fairly common, and in the southeastern corner the basswood and Kentucky coffee-tree (**Gymnocladus dioica**) are present. The dogwood (**Cornus stolonifera**), hawthorn (**Crataegus mollis, C. macrocantha, C. Sheridana**) and hawthorne (**Viburnum lentago**) are more abundant than in the flood-plain woods. Grasses are less important. Prominent herbs in addition are the wild licorice or loosestrife (**Steironema ciliatum**), the nettle (**Urtica gracilis**), alum-root (**Heuchera hispida, H. valifolia**), snake root (**Sanicula Marylandica, S. cendensis**), beggars' tick (**Washingtonia longistylis**), and bedstraw (**Galium triflorum**). Twiners are **Smilax hispida, Clematis occidentalis** and hop (**Humulus lupulus**). Dutchman's breechers (**Dicentra cucullaria**), jack-in-the-pulpit (**Arisaema triphylum**), columbine (**Aquilegia canadensis**), **Trillium erectum** and many other plants common in the woods to the east of South Dakota are represented in the woods of the southeastern and northeastern corners of the state.

The birds in addition to those common in woodlands, which nests most commonly in wooded ravines is the oven-bird. Many warblers stop in such areas during their migration. It is not known that there are any mammals peculiar to this association.

The copses found near the heads of various north-facing ravines are a special phase of the ravine woodland. Their location is deter-

[67] Conspicuously species of Prunus, Rhus and Crataegus.
[68] Shelford, V. E.: Principles and Problems of Animal Geography (Mss.)

mined by the presence of a spring, or at least of seepage. Plums (**Prunus americana**), chokecherry (**P. melanocrapa**), ash (**F. lanceolata**), Juneberry (**Amelanchier alnifolia**), and hawthorn (**Crataegus sheridana**) are the more common trees and shrubs, the horsemint (**Monarda menthaefolia, M. fistulata**) the most conspicuous herb, and the Arctic towhee the most common bird.

### (D) WOODS ON BLUFFS

In the southern part of Gregory and Tripp counties, and on portions of the bluffs of the Missouri in Clay and Union counties, and of the Sioux in Union and Lincoln counties there are scattered clumps of burr oak (**Quercus macrocarpa**) and sumac (**Rhus glabra**) with patches of buck-bush (**Symphorocarpus racemosa**) here and there. The chief grasses are bunch grasses (Andropogon, Aristida). The western field sparrow nests commonly in this association.

### (E) PINE FORESTS

There are about 1,400,000 acres of forest reserve in South Dakota, approximately 100,000 acres in Harding County, and the rest in the Black Hills. In the Black Hills there are tens of thousands of acres fairly well-timbered but not in the federal reserve. The geographic conditions in these forests have been treated in the discussion of the Black Hills bio-geographic district and in the chapters on physiography and climate. The chief commercial tree in the reserves is the Rocky Mountain pine (**Pinus [ponderosa] scopulorum**). The red cedar (**Juniperus scopulorum**) is important at lower elevations, and the white spruce (**Picea alba**) near the summits of the Black Hills. Ash (**F. lanceolata**) and other trees (Elm, hackberry) valuable for fence posts, are found in the valleys at low elevations.

In addition to the pine, cedar, spruce and ash there are elms (**Ulmus fulva, U. Americana**), birches (**Betula papyrifera, B. fontinalis, B. glandulosa**), poplars of several sorts, including the cottonwood (**Populus [occidentalis] sargenti**), quaking aspen (**P. tremuloides**), and narrow-leaved poplar (**P. angustifolia**), and other trees and shrubs, making a total of about 120 species of woody plants, representing about 30 families. Of these some 37 species are trees and 74 species shrubs. The herbaceous flora is very rich.[69]

Among the more common birds are the Lewis woodpecker, western woodpewee, white-winged junco, pinion jay, western tanager, cedar waxwing, Audubon warbler, western house wren, long-tailed chickadee, western robin, and mountain bluebird.

The chief larger mammals are the chipmunk (**Eutamias m. minimus**), Dakota red squirrel (**Sciurus hudsonius dacotensis**), wood-chuck (**Marmota dacota**), wood rabbit (**Sylvilagus audubonii bailevi**), white-tailed deer (**Odocioleus americanus macrouris O. texanus**), bobcat (**Lynx c. canadensis, L. r. rufus**) and pocket gopher (**Thimomys talpoides nebulesus**). The reptiles are the green garter snakes. Amphibians are salamander (Amblystoma tigrium) and a species of frog.

[69]Rydberg, P. H.: Flora of the Black Hills. Contrib. U. S. Natl. Herb. III (1896): 463-536; Visher, S. S.: Additions to the Flora of the Black Hills: Torreya IX, 1909, pp. 186-188, Muhlenbergia VIII, 1912, pp. 135-137, ibid IX, 1913, pp. 33-39.

## V. THE AQUATIC AND SEMI-AQUATIC GROUP OF ASSOCIATIONS

### (A) In General

#### 1 Distribution

The official estimate of the area permanently covered by water in South Dakota is but 747 square miles. This includes the major rivers of the state, together with the larger streams in the Black Hills, and the larger lakes mentioned in the chapter on physiography. It is likely that at least ten times that area commonly or frequently is submerged. Thousands of small lakes go dry but seldom, and many "lake beds" contain standing water occasionally. The streams of the state are liable to overflow their banks, and as a result there are considerable tracts which are somewhat aquatic in character. The major aquatic areas are on the eastern Choteau (p. —). During wet years there are numerous marshy or submerged tracts in the rest of the glaciated part of the state (Fig. 2), and also in the Great Plains where there are "blow-outs."

The members of this group of associations are (1) marshes, (2) ponds, (3) lakes, (4) streams (a) brooks, (b) creeks, (c) rivers.

#### 2 Geographic Conditions

The presence, in areas permanently submerged, of an abundance of water produces a sharp contrast between such areas and the upland parts of the state. Not only is there sufficient moisture, but other conditions are greatly modified. In portions which do not freeze, the annual range of temperature is no more than 30° or 40° F. instead of at least 120°, a range experienced by most places exposed to the air. In bodies of water which freeze over, the range in most places is much less than that experienced on the land. The daily range of temperature in submerged and even boggy areas is very much less than occurs elsewhere in this region. The light conditions are very different also. However, the shallowness of most bodies of water permits of the penetration of diffused light to the bottoms of nearly all, if not all lakes in the state. Marsh plants and other species which reach up into the air, and such animals as emerge from the water are affected by wind and sun, and suffer loss of moisture, and are battered about by the winds.

The soil conditions in many submerged areas are similar, as a soft alluvial or lacustrine silt is general. Coarser materials, especially cobbles and pebbles have associated with them quite different animals and plants than "muddy" areas.

#### 3 The Dominant Plants and Animals

Relatively few species are found in all sorts of water bodies, although many are widely distributed. Examples are certain algae, pondweed (Potomogeton), duckweed (Lemna), water buttercup (Batrachium trichophyllum), milfoil (Myriophyllum spicatum), several sandpipers (the spotted, solitary, yellowlegs, and Baird sandpipers, Wilson's phalarope and killdeer), the muskrat (Fiber ziberthicus cinnamoninus), snails,[70] numerous insects such as the water boatman, water striders (Gerridae) dragon flies (Aeschnidae Libellulidae) and others, leeches and protozoa. Many plants and animals less generally distributed will be noted below under the appropriate heads. Here it may properly be remarked that the submerged flora, microscopic forms excepted, is

[70]Lymnaea palustris, L. caperata, L. obrussa, Physa gyrina, Planorbis trivolvus, P. parvus.

poor in species, while that on the near-by wet ground is very rich; that only two or three species of mammals spend much of their time in the water, and that no bird does so. The most aquatic birds merely dive occasionally; none can hatch their eggs except in relatively, although in some cases not entirely, dry nests. The turtles of the state are aquatic (except a box turtle in the sandhills of Bennett County) and the young amphibians also, although the toads leave the water soon after hatching, and the frogs spend most of their lives on land. The invertebrate fauna is far richer than that of any other formation in the state but it has not been studied in detail yet.

### 4 Characteristics of Aquatic Life

Aquatic plants and animals have striking characteristics.

The plants are chiefly semi-aquatic grasses and herbs, most of which are biennials or short-lived perennials. Very few are annuals. Ordinarily there is an abundance of available water, and transpiration can be freely indulged in; occasionally, however, the soil becomes partially dry. The plants which are most successful in a region where such drying-up occurs frequently are those which can resist evaporation. Fertilization occurs largely through the agency of insects, and the seed distribution by means of waves, currents, and animals as well as by the wind. Several "ticks" (Bidens) obviously are adapted for animal distribution. Many, if not most aquatic plants also propagate by root-runners

The birds nest chiefly in reed-hung or floating nests. The females and nestlings are,, in almost every case, streaked and consequently protectively colored. All species are from infancy swimmers or waders. The bills are chiefly sharp and adapted to impaling, or to probing (the tip of the upper mandible being capable of independent movement), or are supplied with strainers.

The mammals are all semi-aquatic and rear their young above the water-level, in burrows or houses. The muskrat, mink **(Mustela vison latifer)** and beaver **(Castor c. canadensis)** are examples.

The snakes and turtles travel freely on land and lay their eggs or bring forth their young there, but spend much of their time in or on the water.

The amphibians are of two sorts, the aquatic salamanders **(Amblystoma tigrium)** and the semi-aquatic frogs **(Rana pipiens, Acris gryllus)**. The adaptations of frogs to life on land, by the growth of legs and other changes, is too well known for more than mention, but the changes undergone suggest the striking differences between the habitats.

Fishes resemble tadpoles in many respects. The habit of swimming against the current, which most fish inhabiting swift streams have, is an interesting method, also used by various invertebrates, of preventing their being washed away by the current.

Almost all of the insects characteristic of aquatic areas spend a portion, in many cases the larval stages, of their life in the water. Examples are mosquitoes, dragon-flies, damsel-flies, may-flies, water beetles and water-boatmen.

### (B) Marshes

Marshy areas are found in all parts of the state, but they are more numerous and extensive in the eastern third than elsewhere. Most marshes are in depressions in the surface of the drift-sheet, but

[7]Polygonum hydropiper, P. lapathifolium, P. Muhlenbergii, P. pennsylvanicum, P. persicaria.

there are some along streams, in "blow-outs" (p. —), or about springs. Many areas which are often submerged to a slight depth do not develop into marshes because of the frequency of the disappearance of the water. Marsh vegetation requires soil almost continually water soaked.

The marshes of South Dakota may be classed as (a) those with a low vegetation of broad-leaved plants and (b) those with tall grass-like plants.

(1) Many marshy areas have a dense growth of smartweed, several species of which are abundantly represented in this area. The marsh flax (**Coreopsis tinctoria**) grows as a secondary species in many little marshes, and makes them gaudy for several weeks with yellow and maroon colored flowers. This type of marsh appears to be far less attractive to birds than does the other. No species of bird is common in smartweed marshes, nor does the muskrat frequent such places.

(2) Areas occupied by tall grasses and reeds more often are thought of as marshes than the preceding type. In this state there are three chief types, (1) those dominated by slough or cord grass (**Spartina**), (2) sedge (**Carex, Scirpus, Cyperus**) marshes. (3) red grass (**Calamogrostris**) and cat-tail (**Typha**) marshes. Wild rice (**Zizania palustris**) is found especially in reed marshes in the northeastern corner of the state and the mountain rice (Oryzopsis) in the Black Hills.

The chief marsh birds are the thick-billed redwing blackbird, yellow-head blackbird, sora and Virginia rails, American bittern, black tern and certain ducks, such as the pintail and mallard, which nest near such marshes, especially where they are contiguous with open water. The leopard frog (**Rana pipiens**) attracts the night-heron. The salamander (**Amblystoma tigrinum**) is common in the larger marshes. The muskrat is the only mammal associated with isolated marshes. The turtle or terrapin (**Melacoclemnys geographica**) frequently migrates into such marshes. There are in this state four species of snails which are found commonly in marshes only.

### (C) Ponds

Ponds differ from marshes chiefly in lacking conspicuous vegetation. There is a variety of ponds: (1) very temporary ponds on land which is cultivated after the water disappears; (2) temporary ponds in blow-outs. In many cases in the western part of the state the soil of the blow-outs is surcharged with salts, and bottom nearly devoid of vegetation; (3) temporary pools (water-holes) along the courses of temporary streams. In each of these three sorts of ponds there are many algae and a short-lived fauna of entomostraca (**Copepods**) and the more minute invertebrates, at least ten species of snails,[72] and many insects. Mosquitoes are very abundant, much more so than about areas containing fish and frogs. These temporary ponds are very attractive to shore birds, and in the proper season scores of individuals representing numerous species may be seen on the margins. The Killdeer and Wilson phalarope are the two that breed most abundantly, most of the others being migrants, but spending as long a time here as in their Arctic breeding grounds. After such ponds dry up, the larger areas may be occupied with squirrel tail grass (**Hordeum jubatum**). The little waterholes in many cases contain the four-leaved clover (Marsilia) which matures its seeds only after exposure. Permanent or nearly permanent ponds are bordered by a greater variety of vegetation and possess a more varied fauna than temporary ponds.

[72]Lymnaea palustris, L. stagnalis oppressa, Planorbis parvus, Physa sayi. [73]In ponds of classes (1) and (2): Planorbis trivolus, P. bicarinatus in waterholds: Lymnea bulimoides cockerelli, L. caperata, L. obrussa, Pisidium contortum, P. overi.

### (D) Lakes

Lakes differ from ponds in respect to depth: bodies of standing water deep enough not to freeze to the bottom are in this region usually called lakes, even though their expanse is slight. The shallower lakes or parts of lakes may have an abundant vegetation of submerged plants, in some places of water crowfoot (Batrachium), milfoil (Myriophyllum), pondweed (Potomogetan), hornwort (**Ceratophyllum demersum**) or in some of the larger lakes of water lilies (**Nymphaea advena**). The duckweed (**Lemna minor**) is an abundant floating plant in many lakes. Marshy tracts are found about many, and the fluctuation in level of a majority, since a majority have no outlets, is sufficient to produce marginal portions which resemble temporary ponds.

A large number of birds occur as migrants; for example, some twenty-five species of ducks are recorded[74] from the lakes of eastern South Dakota. Several species of water birds secure their food from lakes or from marshy tracts adjacent. Three grebes (pied-billed, eared, and western) are fairly common or locally abundant in South Dakota, as are several ducks (ruddy, scaup, baldpate). Mallards, pintails, and blue-wing teal also nest abundantly in marshy tracts bordering lakes, as do other birds mentioned under "marshes." The Franklin gull nests on many of the larger lakes of the northeastern part of the state, but secures most of its food (chiefly grasshoppers) from fields and grasslands.

The only abundant mammal is the muskrat, but the mink, which preys upon it, is not uncommon, and the beaver, formerly was plentiful.

Both of the two common South Dakota turtles, the terrapin and the snapping turtle, are found in lakes, but the latter is more abundant in streams.

There are three species of bivalve mollusks and various snails.[75] Several fishes (carp, black bass and bullheads) have been introduced into lakes, but aside from these, few lakes have fish of considerable size.

### D Streams

The streams of South Dakota may be grouped into rivers, creeks and brooks. Rivers are of two distinct types, (a) the sluggish streams of the eastern section of the state, and (b) the swift streams of the western part. Streams which go dry nearly every year in parts of their courses usually are called creeks. Brooks differ from the other streams in being fed chiefly from springs and hence normally clear. They are also permanent and swift flowing. The "creeks" in the Black Hills are considered here as brooks. The brooks in the sandhills and in the forested buttes are nearly all very short. The fauna and flora in or bordering streams is rich in species.

(a) **Plants.** In many places there are trees along streams; western cottonwoods and several willows are very generally distributed; the dogwood overhangs many brooks and also pools in creeks. The horsetails (Equestum) and various sedges (Carex, Scirpus, Cyperus) and rushes (Juncus), notably the spike-rush (Eleochris) are abundant on the moist margins of streams, where various species of dock (Rumex) are very conspicuous late in the season. The water plantain (Alisma), arrowhead (Sagittaria), and several species of buttercups (Ranunculus, Halerpestes) are found along streams not liable to frequent wide fluctuations in volume, or if such fluctuations occur, do not then transport large quantities of coarse, cutting materials.

In rivers and the less permanent parts of the creeks vegetation is chiefly microscopic. In the deeper pool of creeks various attached

[74]Visher, S. S.: The Birds of Sanborn County, S. D., The Auk, 1913; of Clay County, Wilson Bulletin, 1915.

submerged plants, including the water buttercup (Batrachium), false water-cress (Roripa), pond-weed (Potomogeton) and stone-wort (hara fortid) may be found. In brooks, the true water-cress (Cardemine) is abundant, and in many places the matgrass (Catabrosa), and there is a rich flora along the margins. The willow herb (Epilobium), mint (Mentha), hyssop (Gratiola), water horehound (Lycopus), water hemlock (Cicuta), arrowgrass (Triglochin), marigold or beggars' tick (Bidens), monkey flower (Mimulus), St. John's wort (Hypericum), thoroughwort (Eupatorium), skull cap (Scutellaria), and others are widespread along brooks.

(b) **Animals.** Several birds are found most frequently along streams. Examples are the belted kingfisher, great blue and little green heron, and the black-crowned night heron, spotted and solitary sandpipers, killdeer, and green and blue-winged teals and pintail ducks. The wood duck formerly was common along the streams of eastern South Dakota. The American dipper or water ousel is abundant on the streams in the Black Hills.

The mammals found about the streams are the muskrat **Fiber zithoides cinnaonus)**, beaver **Castor c. canadensis)**, which still is found in each quarter of the state, and mink **(Mustela vison latifera)**. Formerly the otter **(Lutra c. canadensis)** was represented.

The reptiles are the garter snake **(Thamnophis sirtalis)**, which is very abundant, and snapping turtle **(Chelydra serpentina)**. In creeks the last is found only in the deeper pools.

The only amphibian which is widely abundant along streams is the leopard or grass frog **(Rana pipiens)**.

The fish of the state are few in number as well as comparatively small in size. This condition appears to be correlated with the character of the streams. It is seldom that a catfish (Ictalurus) weighing more than ten pounds is caught except in the Missouri River, the deepest stream of the state, and the record for the state is placed at twenty-five pounds. In the lower Mississippi River the same species attains a weight of 100 pounds. Bullheads (Ameiurus), catfish (Ictalurus), carp (Cyprinus), buffalo-fish (Ictiobus), suckers (Catosomus)( and shiners or minnows (Notropis) are abundant in the larger streams. Pickerel (Esox), pike (Esox), sunfish (Lepomis), perch (Perca), gar (Lepiososteus) and the red-horse (Moxostoma) also are represented in most rivers. In the brooks there are darter (Boleosoma), dace (Phoxinus), trout (Salvelinus) and minnows (Notropis).

The mollusca of sluggish streams in the eastern part of the state include a variety of Unios, Anodonta, Quadrula and Sphaerium. Anodonta **(A. grandis)** is the most abundant clam recorded from the western half of the state. The fact that the western rivers are frequently raging torrents and carry stones of considerable size is the probable explanation of the scarcity of clams. In pools, "water holes," along creeks are found several snails of three genera.[77]

Many other invertebrates are found in or about streams. The fresh

[75]Anodonta grandis; Lampsilis luteolis, Symphynota complanata; Valvata tricarinata, Planorbis exavatus, P. parvus.

[76]A. grandis is most widespread. Q. lachrymosa is common in the more sluggish sections, while Q. undulata is found in the swifter current. S. sulcatum and S. partumerium are found in sluggish sections and S. striatinum accuminatum in the swifter portions. Lampsilis luteolus, more characteristic of sandy margins of small lakes, occurs occasionally on similar portions of streams.

[77]Lymnea bulimoides cockerelli, L. caperata, L. obrussa, Pisidium contortum, Planorbis trivolvus, P. bicarinatus.

water shrimp (Gammarus) and the planarian flat-worm (Planaria, Dendrocoelum), are exceedingly abundant about some streams, as is the snail Zonitoides. rawfish (Cambarus) are widespread. Water-beetles, water-boatmen (Corixa), backswimmer (Notonecta), damsel flies, mayflies, mosquitoes and black flies (Simulium) are numerous. The larvae of the latter builds a case of tiny pebbles about itself, and the "houses" of "caddis flies" are very abundant on submerged rocks in the swifter and clearer streams.

From the preceding discussion, it appears that the native flora and fauna have been influenced powerfully by geographic conditions. The human life, treated in the following chapter, has been affected to a lesser degree, but nevertheless, greatly.

# CHAPTER SEVEN

## HUMAN GEOGRAPHY

1. Present conditions, p. 109; the evolution of the present conditions, or The General Historical Geography, p. 129.

### (A) The Population and Its Composition

The population of this area, as returned by the several federal and state censuses, was as follows:

| Year | Population | Increase Over Preceeding Census Year | Percentage of Increase | Density per Square Mile |
|---|---|---|---|---|
| 1870 | 11,925 | ..... | ..... | .16 |
| 1880 | 98,711 | 86,786 | 853 | 1.2 |
| 1885 | 262,560 | 163,849 | 156 | 3.4 |
| 1890 | 348,662 | 86,102 | 32.3 | 4.5 |
| 1895 | 330,975 | 17,687 | 5 | 4.3 |
| 1900 | 401,570 | 70,595 | 21.3 | 5.2 |
| 1905 | 455,185 | 53,615 | 13.4 | 5.9 |
| 1910 | 583,888 | 128,703 | 28.3 | 7.6 |

The federal census[1] records a large but relatively decreasing foreign-born element in the population (17.2% in 1910, 22% in 1900, 26.1% in 1890). The proportion of foreign-born persons is higher in the rural than in the urban districts (17.4% vs. 16.3% in 1910). Five counties reported no foreign-born persons in 1910, fifty-one reported between 10% and 25%, and four counties more than 25%. Of the foreign-born in 1910 37% were Scandinavians (Norway, 20.8%; Sweden, 9.9%; Denmark, 6.3%), while natives of Germany made 21.4%, Russia 13.1%, Canada 6%, Austria 5.3%, England 4%, Ireland 3%, Holland 2.6%, leaving 7.61 % for all other nationalities represented.

The percentage of the population reported as native-born with one or both parents of foreign birth (37.2% in 1910, 38.9% in 1900, 32.4% in 1890), is nearly twice as large as the foreign-born element.[2] Of these two elements making up the so-called population of foreign origin, (54.4% of the total population in 1910, 60.9% in 1900, 57.5% in 1890), in 1910 Germany had contributed 26%, Norway 19.1%, Russia 10.4%, Sweden 7.3%, Canada 6.3%, Ireland 5.5%, Denmark 4.7%, England 4.7%, Austria 4,2%, Holland 2.1%, Scotland 1.3%, Finland 1%.[2] If to the large per cent (26) accredited to Germany, the Germans born in Austria and Russia and their children could be added, it is probable that the Germanic element in the state would exceed the Scandinavian (31.1%). Most of the Russians are Teutonic Mennonites and most of the Austrians are Teutonic Bohemians.

The rest of the white population (42.1% in 1910, 33.1% in 1900) is native-born of native-born parents. Of this element more than half (53.4% in 1910, 41.4% in 1900, 65% in 1890) were born in other states or territories. The seven states that contributed most, with the per cents for 1910 and for 1900 are Iowa (15.7, 9.9); Nebraska (3.8, 2.0); New York 2.1, 3.8); and Ohio (1.8, 2.3). All other states contributed but 11.2% in 1910, and 11.8% in 1900.[3] When grouped by geographic divisions, it appears that of this native element 74.6% in 1910 and 71.1% in 1900 were born in the "West North Central States," as that division is defined in the Census reports, while the "East North Central States" supplied 17.8% and 18.6% respectively. The "Middle Atlantic Division" contributed 3.7% in 1910, and 5.8% in

[1]Supplement for S. Dak., pp. 589-590, (Washington, 1913).
[2]Ibid., p. 590.
[3]Ibid., p. 591.

1900, leaving but 3.9% in 1910 and 4.5% in 1900 for the population contribnuted by the other divisions of the Union. The percentage of the population native to the West North Central States aside from Iowa has fallen off slightly, as the increase (3.5%) shown by this division is more than covered by the large increase (5.8%) from Iowa. The East North Central Division has lost but slightly (1.2%), while the representation sent by the Middle Atlantic and New England sections decreased about a third, in each case, between 1900 and 1910.

As the number of Indians has remained about stationary (19,137 in 1910, 20,225 in 1900 and 19,854 in 1890) they form a decreasing proportion of the entire population (5.7% in 1890, 3.3% in 1910). Negroes have comprised about 0.1% of the population since 1890.

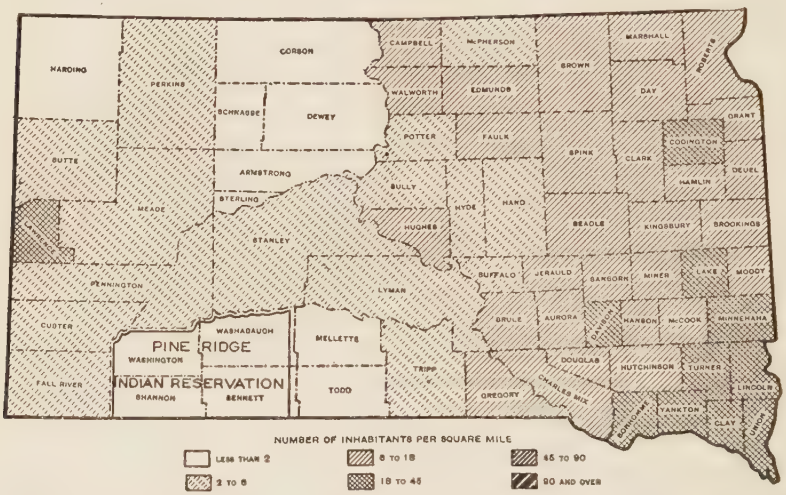



Fig. 30. Density of Population of South Dakota, by Counties, 1910.

### (B) The Distribution of the Population

Fig. 30 shows the density, and thus the distribution, of the population of South Dakota by counties in 1910. The population is most dense in the eastern, especially in the southeastern, part of the state, and least dense in the extreme northwestern county, and in the Indian reservations, present or recent, in the north-central and south-central parts of the state. Mining and irrigation support in the Black Hills region a population much denser than occurs elsewhere in the western half of the state. With the exception of parts of the reservations and of the Black Hills, the population in a general way decreases in density with increased distance from the southeastern corner of the state. It was noted in earlier connections that with the exception of the Black Hills, there is a similar decrease in the amount of rainfall and in the length of the growing season with increased distance from the southeastern corner.

In discussing the distribution of the population, it will be convenient to treat separately the distribution of towns and of the rural population. Since more than two-thirds (66.7%) of the population live outside of towns, the latter will be discussed last.

The density of the "rural" population (all persons not living in

places of more than 2,500) is very similar to that indicated in Fig. 30. However, Codington, Lake, Davison, Hughes, Lawrence and Yankton counties are less densely populated than indicated by Fig. 30, due to the exclusion of the populations of the cities of Watertown, Madison, Mitchell, Pierre, Lead, and Yankton respectively. With the exception of Yankton County, a map of the rural population by counties supports the generalization made for the distribution of the population even better than did the map (Fig. 30) of the entire population.

### 1. Location of Dwellings

Areas subject even rarely to inundation have relatively few homes. A large majority of the buildings in the valleys are on higher ground near the bases of the bluffs, in many cases on alluvial fans and piedmont slopes. Many of the latter also are occupied by "bluff roads." Most of the relatively few homes located on the flood-plains are on spots somewhat higher than their surroundings. Similarly very few homes are located within the "lake-beds," exceedingly numerous in the glaciated part of the state, with the result that a large proportion are near the margins of such depressions. In the more rugged parts of the state, notably the Black Hills, the badlands, and the bluff zones along the streams, the steeper slopes were avoided in locating homes. Throughout most of the state, however, the topography is that of a gently undulating plain, and on nearly every quarter section of land there are many suitable building sites. Consequently a large majority of the homes are located within a few rods of the section line road, and near the middle of one of the sides of the "quarter." This is the most convenient location from the standpoint of access both to the highway and to all parts of the "quarter." Rural free delivery and telephones have increased the desirability of being near rather than far from the main highway. Many farms consist of more than one "quarter,"[4] and in such cases the home is likely to be near the middle of the farm, which lies on both sides of the section-line road. As already noted, there are roads along most section lines, this being practicable because of the slight relief over wide areas. Since most towns of the state are laid out in relation to section or half-section lines, and most rural homes are near such lines, it follows that the latter are the determining factor in the detailed distribution of most of the homes and most of the people. A geographic feature is responsible for the precise location of these lines. In the area east of the Missouri River, the survey of which these lines are a part, used the mouth of the St. Francis River in Arkansas as the starting point. An east-west line through the mouth was made the baseline, a north-south line (which happened to be 90° 58' west from Greenwich) was made the prime meridian.[5] Had the position of the mouth of the St. Francis River been different, and because of the shifting of the Mississippi River it frequently has changed, the distribution of most of the homes in eastern South Dakota, as in parts of certain other north central states, would have been different than it is. The land survey of that section of South Dakota west of the Missouri River used the 44th parallel as its base line.

### 2. The Location of Towns.

The location of almost all South Dakota towns, except some in the Black Hills, is associated closely with railroads. They are spaced

[4]About 1-10 of the farms consist of one and one half "quarters," while nearly one third include two quarters, according to the 13th Census (Supplement for S. Dak., p. 619).

[5]Smith and Young: History and Civil Government of South Dakota, pp. 36-135. (New York, 1904).

at intervals of about ten (eight to twelve) miles along the tracks. Railroads are sufficiently plentiful east of the Missouri so that few localities are more than fifteen miles from a station, and yet few towns are less than eight miles apart. Thus towns have substantially equal advantages in regard to the size of the territory most readily accessible to them.

The seat of local government is such a valuable asset to a town that in most cases the county seat has become the largest town of the county. Consequently, in most new counties there was great rivalry between the towns for the county seat, and the political ambitions of many towns were powerful influences in favor of small counties rather than large ones. Some of the county seats are junction points of two or more railroad lines, and such towns have outstripped less favored ones.

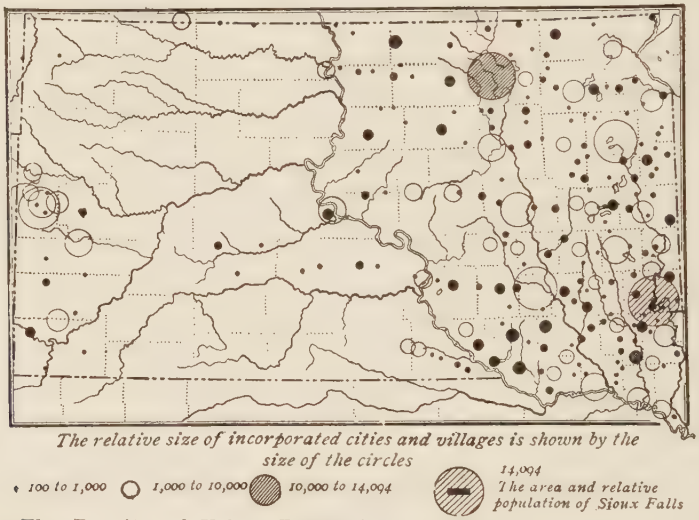

The relative size of incorporated cities and villages is shown by the size of the circles
100 to 1,000
1,000 to 10,000
10,000 to 14,094
14,094
The area and relative population of Sioux Falls

Fig. 31. The Density of Urban Population in South Dakota, Census of 1910.

With few exceptions, the larger cities are fifty miles or more apart. To a certain extent they serve the surrounding towns, as wholesale centers, and sites of relatively advanced educational facilities and amusements. Manufacturing is increasing rapidly in the larger cities.

In regard to towns, the state is divided readily into three sections, though the boundaries are less distinct than they were before 1905: (1) The eastern half of the state; (2) the Black Hills region; (3) the Great Plains section.

(1) **The Towns of the Eastern Half of the State.** Of the ninety towns which in 1910 had a population of 500 or more, all but fourteen are east of the Missouri River. Every one of the ninety towns has a railroad, and ten of the fifteen east of the Missouri, having a populationof more than 1,500, have two or more lines. Of the other five, one is the capital, one the site of the State University, and another the site of the College of Agriculture. The other two are barely within this group.

Of the seventy-six towns under discussion, thirty-eight have but one railroad each. Of these, seven are on railroads which run north-

uth and five are on diagonal lines, while twenty-six are on east-west nes, which as a class are older than the other lines. The thirty-eight maining towns of this group have east-west and either north-south diagonal lines.

Of the seventy-six towns of the eastern group, only three, Pierre, hamberlain and Yankton, are on the Missouri River. Vermilion for-erly was on that stream, but the shifting river is now about two iles away. Only one of these towns, Olivet, is on the Dakota River, ough several (Canton, Sioux Falls, Dell Rapids, and Flandreau are on e Sioux. Yankton Sioux Falls and Vermilion were the only river wns which were of significance before the coming of railroads. ankton was then the capital of the Territory, and although it benefitted eatly by the river in early days, it no longer does. The stream is t bridged, and therefore partially cuts off from the city nearly half e territory which might be expected exclusively to depend on it. ankton has declined with the falling off almost to nil of navigation the Missouri, and the building of a railroad on the opposite side the river. The growth of Vermilion has been slow for similar rea-ns. Chiefly because of the expense and difficulties in bridging the issouri River, several east-west railroads had their termini for many ars on its east bank, with the result that towns grew up there. hamberlain and Pierre are the larger towns whose growth was stim-ated in this way. Running Water and Le Beau are small towns ess than 500) at the termini of railroads, which indirectly owe their istence to the river.

Nearly all the other towns of this part of the state owe their cation to railroads. A large proportion of them were laid out ong the east-west lines, as most of the east-west roads were con-ructed before the main north-south lines. The location of the rail-ads, and hence, in a way, of the towns, was influenced by (1) the esence of preglacial valleys across the relatively high Western Coteau d (2) favorable points for crossing the Dakota River. The main e of the Chicago, Milwaukee and St. Paul, heading for the ack Hills, preempted the southern gap in the Coteau, between e Wessington Hills and the Bijou Hills. Entering Dakota at Canton, e railroad in 1880 was built across the Vermilion River Valley at s forks and across the Dakota River where a tributary stream (Fire-eel Creek) had prepared the way for a relatively easy crossing, by aking a relatively easy grade from the river to the plain on the est. Elsewhere in the vicinity, and for some miles to the south, the kota River flows through a shallow gorge, which it would have been fficult to cross. Mitchell was located on the plain just west of this ossing, from which the line continues westward through the gap in e Coteau to the Missouri River at Chamberlain. The main east-west e of the Chicago and Northwestern Railroad entered Dakota in 1880 om the east near Brookings, swinging north to avoid a group of rge lakes in Kingsbury County, and thence continuing nearly west rough the next gap to the north in the West Coteau and down the lley of Medicine Knoll Creek to the Missouri flood-plain. It fol-wed up this plain to a point opposite the mouth of the Teton River, here Pierre was founded. In 1907 it was continued westward to pid City in the Black Hills. Nearly midway between these two ughly parallel lines, which are about fifty miles apart east of the ssouri River, is the east-west line of the Chicago, Milwaukee and Paul, which entered Dakota near Flandreau and was extended west the western Coteau at Wessington Springs. The location of a con-derable section of this line is said to have been due to the relatively vorable crossing of the Dakota River by way of the small tributary

valley of Silver Creek. In a similar way the other east-west lines, with their attendant towns, were influenced in their location, even in so nearly level an area as eastern South Dakota, by physiographic features.

Near the points where each of the railroad lines crossed the Sioux and Dakota rivers, town sites were laid out, and between these points stations were located ten miles or so apart along the railroads.

The north-south railroad lines are next in importance. The bottom of the Sioux Valley is fertile and nearly level, and by 1875 it had a considerable population. It was followed by the earliest north-south railroad line, completed to Sioux Falls in 1878, and to Flandreau in 1879. Prominent railroad towns in this valley are Elk Point, Canton, Sioux Falls, Flandreau, Brookings, and Watertown. The topography of the Dakota Valley favors railroad building as well as the fertility does agriculture, and the second of the north-south lines was built, mostly in 1883, up the west side of the valley. It increased the importance of several towns already laid out on east-west lines, especially Mitchell, Woonsocket, Huron, Redfield, and Aberdeen, and it led to the establishment of many smaller towns. The territory between the Sioux and Dakota valleys needing railroads, lines were built (mostly in 1886) along the low intervening divide. The towns along these lines are not so large as those in the valleys. The more prominent are Centerville, Parker, Salem, Howard, Madison, Lake Preston, Bristol, and Britton.

Part of the broad divide between the Dakota and Missouri valleys is rugged, and no railroads have followed it entirely across the state. Among the towns in this region, most of them on east-west railroads, may be mentioned Tyndall, Platte, Stickney, Plankington, Wessington Springs, Miller, Highmore, Clark, Gettysburg, Faulkton, Ipswich, and Roscoe.

(2) **The Towns of the Black Hills Region.** The location of most of the towns in the Black Hills was determined by mines, or by passes into the more rugged sections. Custer, Keystone, Galena, Deadwood, and Lead are examples of the former class, and Edgemont, Hot Springs, Rapid City, Sturgis, Whitewood, and Spearfish of the latter, though the growth of Hot Springs was due largely to hot mineral springs. Deposits of gypsum also have been of importance there, as at Rapid City.

(3) **Towns of the Great Plains Section.** This part of the state had no towns until the coming of railroads. Once a year the ranchers drove stock to market towns in the Black Hills, or to the railroads near the Missouri River. In many cases these towns were scores of miles from the ranches. Supplies for months were secured on such trips. The westward extension of the railroads (1906 to 1910) changed conditions greatly, and now there are many small railroad towns in this part of the state. Six railroads have crossed part of this region, four of them following the main divides. Formerly the valleys were inhabited and the divides were unoccupied, but now the divides are the more densely populated belts. Cross-line railroads have not been built, and several of these young towns are so nearly equal in size that it is quite uncertain which will attain leadership. Among the more prominent are Gregory, Dallas, and Winner along the White-Niobrara Divide, Presho, Murdo, and Interior along the White River Valley; Midland, Philip, and Quinn in the Teton Valley; Eagle Butte and Faith on the Moreau-Cheyenne Divide; Timber Lake and Isabel on the Moreau-Grand Divide; and McLaughlin, McIntosh, and Lemmon on the Grand-Canonball Divide.

## (C) THE MORE IMPORTANT OCCUPATIONS

### 1. Agriculture

A large majority of the people in South Dakota are engaged in agriculture. In 1910 only 13.1% of the entire population of the state resided in cities and towns having a population of 2,500 or more, and in 1900 only 10.2%.[6] At the taking of the 1910 census more than 60 per cent of the dwellings were on the 77,644 farms of the state. There were only 5,226 persons engaged in manufacturing, and only 4,169 persons engaged in mining, quarrying, and well-drilling. These industries employed less than 5% of the 197,000 males of 18 years and over. The percentage engaged in commerce and transportation probably is larger than that, but the figure is not available. It appears likely, however, that more than 75% of the workers of South Dakota are engaged in agricultural and pastoral pursuits.

Farming and stock-raising are the leading occupations, largely because of geographic conditions. The wide extent of nearly level, fertile plains, grass-covered, and ready for the plow, and fairly well warmed and watered, encouraged agriculture. In contrast, the treelessness of most of the area determined that lumbering should be unimportant. The lack of highly valuable deposits of coal or iron, or of other minerals outside the Black Hills, prevented mining from assuming the leading place. Manufacturing is handicapped greatly (1) for want of cheap supplies of good fuel or of sufficient water power, (2) by the relatively sparse population, and (3) by the small local market. Because South Dakota is near the center of a great continent, lacks effective natural highways, such as the Great Lakes, is on the border of the more densely populated region to the east, and is separted from the west by mountain barriers, commerce is not likely to attain to a leading rank among the occupations of the people.

The leading types of agriculture (extensive farming of staple cereals and stock-raising) and the kinds of crops grown are responses to geographic conditions. The position of the state far from the chief markets for the produce, and in a vast area having similar climatic and soil conditions, small local markets, and without quick transportation to distant markets, discourages market gardening or the growing of fancy crops. The climate is unfavorable to horticulture, in comparison with that of many other regions. The uncertainty of the rainfall, the scanty population, and the cheapness of land combine to discourage intensive agriculture. On the other hand, the climate, topographically, soil, and native vegetation[7] are all relatively favorable to the grazing industry and to the growing of certain standard crops, notably wheat, oats, corn, and hay.

(a) **Stock-raising.** From the first settlement of the state, a major part of its used area has been devoted to stock-raising. The nutritious native grasses, cured to hay during the dry autumns, and the light snowfall during most winters always will favor this industry. Formerly the presence of much unsettled land, and the ability of stock to travel many miles to market or to shipping points gave grazing a great advantage over farming, the farmer finding vast unsettled stretches of country a menace because of prairie fires and locusts.[8] The cost

[6] U. S. Census: Supplement for S. Dak., p. 661, (Washington, 1913).

[7] The soil of the state has been discussed in Chapter Three (p. 21); the topography in Chapter Four (p. 46); the climate in Chapter Five (p. 72); and the natural vegetation in Chapter six (p. 101).

[8] Grasshoppers or locusts such as those which inflicted great damage to the crops in 1864, 1865, 1873-1875, are grassland species. The breaking up of the sod, their breeding grounds, reduces their abundance. Furthermore the extension of the tilled area reduces the proportional damage done to any unit area.

of transporting crops long distances in many cases was prohibitive or greatly reduced the profit. Because of the variable and uncertain rainfall in most of the state, mixed farming, in which stock-raising formed a prominent part, has proved more profitable than either cereal farming or stock-raising alone. Consequently there continue to be great numbers of stock in South Dakota. The census of 1910 reported more than 1,535,000 cattle, nearly 670,000 horses, nearly 13,000 mules, more than 611,000 sheep, 2,300 goats, and about 1,010,000 hogs.[8a] During many years the livestock sold each year has been second in value to the wheat crop.[9]

Stock-raising was predominant in the area east of the Missouri River during the 1860's and 1870's before the region was served effi-

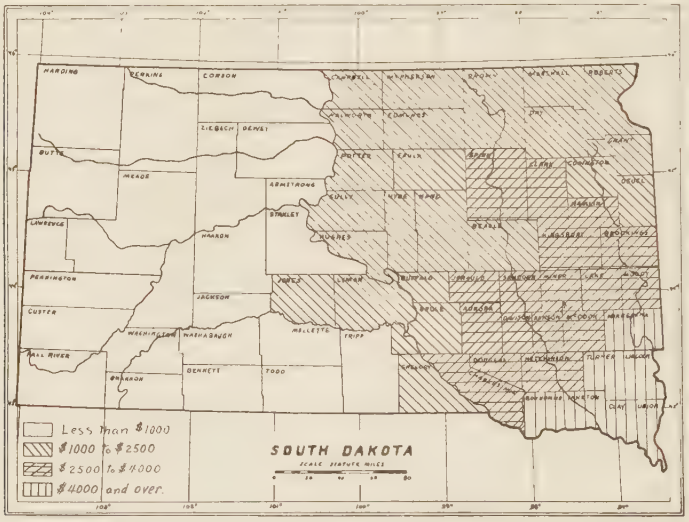



Fig. 32. The Value of Domestic Animals per Sugare Mile, Census of 1910.

ciently by railroads,[10] as Indian agencies and military posts formed excellent markets for beef[11] not needed on the farms and in the towns of the area. The raising of stock was thus highly profitable. "Capital invested in stock usually brings a return of about 50% per annum."[12] "The want of capital is the chief thing that keeps homesteaders from going into stock-raising."[13]

The "Herd-law," making cattle owners responsible for damage done to crops, whether fenced or not, was passed before 1883, and it greatly stimulated tillage,[14] as fencing was expensive.[15] Tillage was encouraged

[8a] Census Supplement: loc. cit., p. 630.
[9] Johnson, Willis E.: Dakota, a Republic of Friends, p. 164, (Pierre, 1911).
[10] Brennan, John: Conditions and Resources of Southern Dakota, p. 27, (Sioux City), 1872).
[11] Foster, James S.: Outlines of the History of Dakota, p. 68, (Yankton, 1870).
[12] Ibid., p. 91.
[13] Brennan: loc. cit., p. 11.
[14] Polk's Gazetteer of Minn. and Dak. for 1882, p. 900, (Detroit, 1882).
[15] "Most of the fence made in Dakota previous to 1870 was of posts and boards or posts and rails mortised. Wire fencing was first extensively introduced in 1870. It cost a dollar a rod." (Foster: loc. cit., p. 90).

still further by a series of wet years (1878-85), and by the extension of railroads. As the land of the eastern part of the area was appropriated by farmers during the early 1880's, stock-raising shifted westward. During the dry years of the early 1890's, when much land in the eastern section was abandoned, herds reappeared in this region, and since then stock-raising has remained important. According to the Census of 1910, the southeastern counties have more livestock per square mile than has any other part of the state (Fig. 32).

Cattle were introduced into the Black Hills region in 1875,[16] shortly after the beginning of the gold rush, and by 1878, the year following the purchase of the region from the Indians, 100,000 cattle, many having been driven from Texas ,were reported from the area almost enclosed by the forks of the Cheyenne. Most of them were in Dakota.[17] There was a very rapid development of grazing in western Dakota during the next few years, induced by the settling of eastern Dakota, Nebraska, and Kansas, and by the extension of railroads to the Missouri River at Pierre and Chamberlain and across Nebraska and the area now included in North Dakota. By 1883 there were 500,000 cattle in the Black Hills region.[18] During the next two years the industry spread to the Little Missouri region[19] and to the Badlands,[20] and according to the Territorial Census of 1885 there were 233,000 cattle, 63,000 sheep, and 10,300 horses in the western third of the area now in South Dakota. Sheep were introduced extensively into Dakota only after 1878. The woolclip of 1880 was nearly 157,000 pounds, while that of 1885 was 882,000 pounds.[21] The grazing industry received severe setbacks by the hard winter of 1886-87, when heavy snow and great cold caused the death of more than 50% of the stock,[22] and by the dry years of the late 1880's and early 1890's. However, it was reported in 1899 that there were 225,000 adult cattle in the sections of South Dakota near the Black Hills,, distributed as to ranges and the number of outfits as follows:[23] Little Missouri Valley, three large and four small outfits, with 68,000 head of cattle; Moreau Valley, two large and two small outfits, with 59,000 head; White River Badlands, five outfits, with 32,000 head; Bad River Valley, three outfits, and 24,000 head; Cheyenne Valley, six outfits, with 24,000 head; the Sandhill district, three outfits, and 16,000 head. During 1896, 1897, and 1898,[24] 7,500 carloads of beef cattle were shipped from Bellefourche, and 110,000 cattle were shipped in 1902. For several years Bellefourche claimed to be the greatest primary cattle shipping market in the world.[25]

Until 1907, grazing continued to be by far the most important industry of the western half of the state, the Black Hills excepted. The chief ranges centered about the White River Valley, the Bellefourche Valley, and the Little Missouri Valley. In each of these areas badlands or "breaks" afforded protection from winter storms, permanent streams supplied water, and pasturage was available, especially on the terraces or "flats" along the streams. Many large "outfits" occupied the range country, and many cattle, mostly "Herefords," as well as many horses and sheep were raised.

[16]Tallent, A. D.: The Black Hills, p. 314, (St. Louis, 1899).
[17]Maudet-Grancy: Colonel and Cowboys, p. 53, (London, 1884).
[18]Andreas, A. T.: Historical Atlas of Dakota, p. 115, (Chicago, 1884); Maudet-Grancy: loc. cit., p. 53.
[19]Tallent: loc. cit., p. 675.
[20]Governor's Report to the Secretary of the Interior for 1884.
[21]McClure, P. F.: The Resources of Dakota, p. 138, (Aberdeen, 1887).
[22]Baldwin, G. P.: The Black Hills, p. 59, (Chicago, 1904).
[23]Tallent: loc. cit., p. 686.
[24]Tallent: loc. cit., p. 683.
[25]"The Bellefourche Irrigation Project," (Chicago, 1912).

The extension of the railroads across the state between 1905 and 1910, during which years nearly 1,000 miles of line were completed, attracted thousands of homesteaders, and their presence made impossible ranching on the enormous scale of earlier years, when tens of thousands of cattle were owned by one individual or company. In much of the western part of the state, however, grazing is the most uniformly profitable industry; and, though range stock is withdrawn on the arrival of homesteaders, animals are numerous in most regions. The large outfits with their picturesque cowboys have disappeared, but there were perhaps 75,000 more cattle in western South Dakota in 1910 than in 1899. The thirteenth census records[26] nearly 400,000 cattle there; of these, probably 300,000 were adults. This great increase in a region considered overstocked in 1899, is not surprising when it is recalled that the range cattle then received almost no care, that because of lack of drinking water in certain seasons many otherwise excellent stretches of range were unoccupied, and that then only the territory within reach of water holes was stocked. With the settlement of the area, thousands of reservoirs have been constructed, the unoccupied tracts have diminished greatly, and supplies of hay have reduced winter losses. Wolves and coyotes also are less numerous than formerly.

**Table 16—Statistical Data for South Dakota.**

**From U. S. Statistical Abstract and U. S. Census Reports.**

| Year | 1910 | 1900 | 1890 | 1880 |
|---|---|---|---|---|
| Population | 583,888 | 401,570 | 348,662 | 98,711 |
| R. R. Mileage | 3,947 | 2,850 | 2,610 | 1,225 (Dak. T.) |
| Cattle (thousands of) | 1,535 | 1,204 | 717 | 207 (Dak. T.) |
| Horses (thousands of) | 669 | 434 | 253 | 42 (Dak. T.) |
| Mules (thousands of) | 12 | 6 | 7 | |
| Sheep (thousands of) | 611 | 507 | 239 | 85 (Dak. T.) |
| Swine (thousands of) | 1,009 | 823 | 590 | |
| Tilled Area (in thousands of acres) | 12,227 | 8,849 | | |
| Acreage of Cereals (in thousands of acres) | 8,203 | 6,211 | 3,702 | 453 (Dak. T.) |

[26]Supplement for S. Dak., pp. 630-636, (Washington, 1913).

## (b) FARMING

In the eastern half of the state, farming is the most important agricultural activity. The value of the leading products as shown by the census of 1910 is given in Table 17.

| CROP. | Farms reporting. | Acres harvested. | QUANTITY. Amount. | QUANTITY. Unit. | Value. |
|---|---|---|---|---|---|
| Cereals, total | ..... | 8,203,519 | 174,903,749 | Bu... | $98,953,050 |
| Corn | 49,277 | 2,037,658 | 55,558,737 | Bu... | 26,395,985 |
| Oats | 45,127 | 1,559,643 | 43,565,676 | Bu... | 16,044,785 |
| Wheat, total | 39,496 | 3,217,255 | 47,059,590 | Bu... | 42,878,223 |
| Common winter | 1,931 | 65,309 | 952,111 | Bu... | 903,047 |
| Common spring | 29,528 | 2,205,397 | 30,262,554 | Bu... | 29,391,215 |
| Durum or macaroni | 13,650 | 946,549 | 15,844,925 | Bu... | 12,583,961 |
| Emmer and spelt | 13,624 | 259,611 | 6,098,982 | Bu... | 2,627,533 |
| Barley | 28,704 | 1,114,531 | 22,396,130 | Bu... | 10,873,522 |
| Buckwheat | 157 | 1,904 | 28,551 | Bu... | 16,816 |
| Rye | 679 | 13,778 | 194,672 | Bu... | 115,126 |
| Kafir corn and milo maize | 23 | 139 | 1,411 | Bu... | 1,060 |
| Other grains and seeds with acreage report, total[1] | ..... | 521,185 | 4,775,760 | Bu... | 7,025,700 |
| Dry edible beans | 659 | 809 | 5,285 | Bu... | 12,575 |
| Dry peas | 89 | 1,783 | 10,598 | Bu... | 11,223 |
| Flaxseed | 14,614 | 518,566 | 4,759,794 | Bu... | 7,001,717 |
| Seeds with no acreage report, total | ..... | ..... | ..... | ..... | 620,484 |
| Timothy seed | 2,591 | (2) | 371,950 | Bu... | 492,466 |
| Clover seed | 194 | (2) | 2,910 | Bu... | 23,593 |
| Alfalfa seed | 254 | (2) | 4,557 | Bu... | 37,511 |
| Millet seed | 289 | (2) | 32,752 | Bu... | 25,715 |
| Other tame grass seed | 73 | (2) | 12,454 | Bu... | 15,285 |
| Flower and garden seeds | 6 | (2) | ..... | ..... | 25,914 |
| Hay and forage, total | 54,927 | 3,435,656 | 3,651,024 | Tons.. | 15,243,664 |
| Timothy alone | 8,975 | 178,881 | 248,927 | Tons.. | 1,249,390 |
| Timothy and clover mixed | 5,725 | 129,995 | 218,371 | Tons.. | 1,186,035 |
| Clover alone | 242 | 2,693 | 4,194 | Tons.. | 23,971 |
| Alfalfa | 4,428 | 66,183 | 153,906 | Tons.. | 919,946 |
| Millet or Hungarian grass | 4,399 | 35,625 | 65,844 | Tons.. | 293,563 |
| Other tame or cultivated grasses | 1,279 | 51,744 | 55,595 | Tons.. | 230,413 |
| Wild, salt, or prairie grasses | 45,620 | 2,913,676 | 2,798,263 | Tons.. | 10,814,343 |
| Grains cut green | 1,204 | 24,409 | 28,186 | Tons.. | 153,967 |
| Coarse forage | 2,740 | 32,427 | 77,671 | Tons.. | 371,516 |
| Root forage | 18 | 23 | 67 | Tons.. | 520 |
| Potatoes | 44,829 | 50,052 | 3,441,692 | Bu... | 1,967,550 |
| Sweet potatoes and yams | 30 | 7 | 866 | Bu... | 861 |
| Sundry minor crops, total | ..... | 64 | ..... | ..... | 3,528 |
| Broom corn | 14 | 64 | 35,400 | Lbs... | 3,408 |
| Tobacco | 11 | (3) | 860 | Lbs... | 120 |

[1]Includes small amounts of broom corn seed, peanuts, sorghum cane seed, and sunflower seed.

[2]The entire acreage from which these seeds were secured is believed to be included in the acreage given elsewhere for hay and forage, flowers and plants, etc.

[3]Reported in small fractions.

Nearly four-fifths (78.8%) of the total value of crops in 1909 was contributed by cereals, 12.1% by hay and fodder, 5.6% by grains and seeds other than cereals, and the rest (3.5%) by minor crops, chief of which is potatoes.

Corn surpasses wheat in yield though not in value, and is the chief crop in the southeastern quarter of the state (Fig. 33). 'South Dakota raises more corn than Minnesota or Michigan, and twenty-five times as

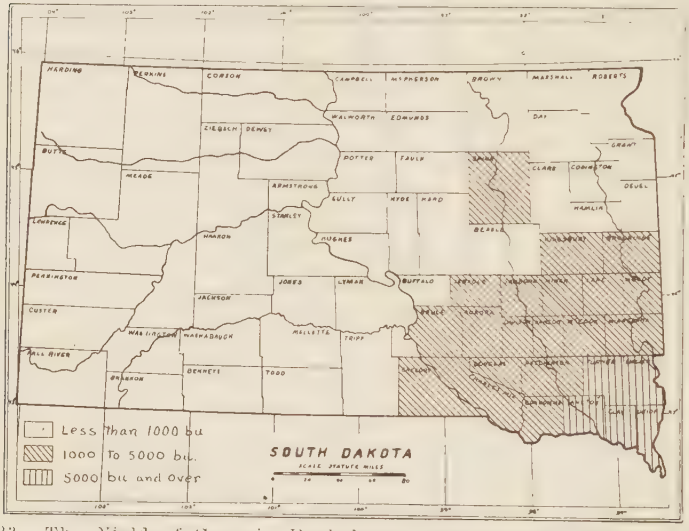



Fig. 33. The Yield of Corn in Bushels per square mile, Census of 1910.

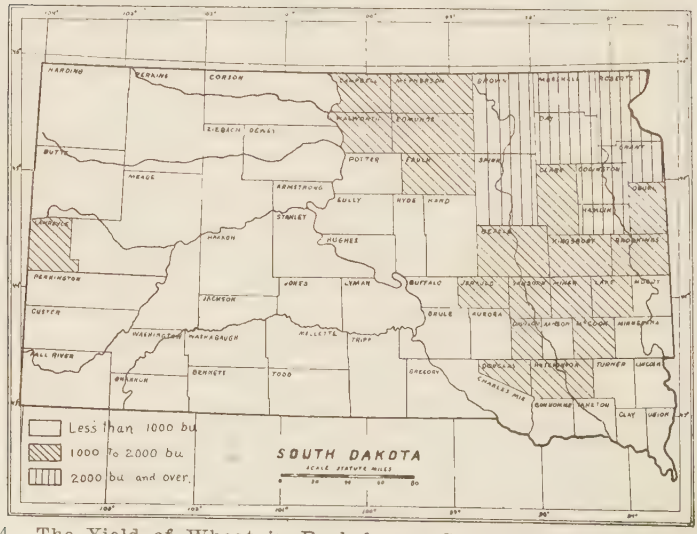
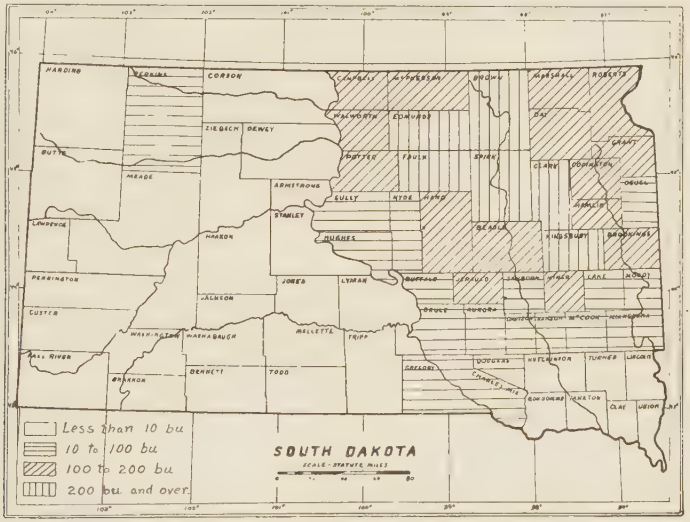



Fig. 34. The Yield of Wheat in Bushels per Square Mile, Census of 1910.

uch as North Dakota. She produces more than all the New England tates combined, with New York, North Dakota, New Jersey, Delaware, ontana, Utah, Washington, Oregon, California, Colorado and Wyoming."[22]

Although some crops have been grown in South Dakota from early ays,[23] there have been notable changes in agricultural practice. In oneer days, wheat was the chief crop.[24] It still is predominant in e northeastern quarter (Fig. 34). Much recently "broken" land is wn to flax, and during the early 1880's this was an important crop the eastern half of the area, as it has been in the western half uring the past decade (Fig. 35).




g. 35. The Yield of Flax Seed in Bushels per Square Mile, Census of 1910.

A period of two-crop farming succeeded that in which wheat was chief importance, wheat and corn being rotated commonly in all but e northern counties, where wheat and oats, barley, or rye alternated. ne dry years of the early 1890's encouraged still further diversification. falfa and other forage crops, barley, oats, corn, flaxseed, potatoes, d fruits[25] have increased greatly in importance and cultivation is more tensive.[26] One result of this development has been an increase in e numbers of dairy cows and hogs, as well as of beef cattle.

The fluctuations in the acreages of some of the principal crops of uth Dakota from 1879-1913 are shown in the next table. The acreage voted to corn is more than three and a half times as great as in 89, both the absolute and the relative gain of 1909 over 1899 being eater than during the preceding decade. The increase in the acreage

[27]Johnson: loc. cit., p. 63.
[28]Polk's Gazetteer of Minnesota and Dakota for 1882, p. 901 records that akota exports wheat, corn, barley, flaxseed, flour, hogs, cattle, butter, eggs, ol and hides."
[29]Johnson: loc. cit., p. 64; Bailey: loc. cit., p. 7.
[30]Fruit raising commenced about 1868. There was a nursery at Yankton 1870 (Foster: loc. cit., p. 89). The Yankton County fair for 1888 exhibited varieties of locally grown apples (Hagerty, F. H.: Dictionary of Dakota, 2, (Aberdeen, 1889).

of oats has been great, but less regular. The acreage of wheat increased from 2,259,846 in 1889 to 3,984,659 in 1899, an advance of 76.3 per cent, but decreased during the last decade to 3,217,255, a decline of 19.3 per cent. The acreage of barley increased more than 1,000,000 acres during between 1889 and 1909. The acreage of flaxseed decreased between 1889 and 1899, but increased much more during the next decade. Hay and forage have made important gains during each of the two decades in question and in 1910 they had an acreage more than twice as great as in 1889.

**Table 18.**

**Acres Harvested.**

| Crop Yr. | Corn. | Oats. | Wheat. | Barley. | Flaxseed. | Hay & Forage |
|---|---|---|---|---|---|---|
| 1913 | 2,640,000 | 1,590,000 | 3,795,000 | 110.000 | 425,000 | 460,000[2] |
| 1909 | 2,037,658 | 3,217,255 | 1,114,531 | 1,114,531 | 518,566 | 3,435,656 |
| 1899 | 1,196,391 | 691,167 | 3,984,659 | 299,510 | 302,010 | 2,287,875 |
| 1889 | 753,309 | 580,289 | 2,259,846 | 97,370 | 354,951 | 1,554,913 |
| 1879[1] | 90,852 | 78,226 | 265,298 | 16,156 | ..... | 188,792 |

[1]Dakota Territory prior in 1889. [2]This acreage does not include wild hay.

The following table shows for 1909 and 1899 the percentage which the farms reporting specified crops formed of all farms, the percentage of improved land devoted to these crops, and the percentage of increase or decrease in the acreage of each crop during the decade, together with the average yields and average values per acre for 1909:

**Table 19.**

| CROP | Percent of Farms Reporting 1909-1899 | | Percent of Improved Land 1909-1899 | | Percent of Increase in acres 1899-1909 | Average Yield per acre 1909 | Average Valu per acre 1909 |
|---|---|---|---|---|---|---|---|
| Corn .....63.5 | 65.8 | 12.9 | 10.6 | 70.3 | 27.3 Bu. | $12.95 |
| Oats ..... 58.1 | 61.9 | 9.8 | 6.1 | 125.5 | 28.0 Bu. | 10.29 |
| Wheat .....50.9 | 79.1 | 20.3 | 35.3 | 19.3 | 14.6 Bu. | 13.33 |
| Emmer & Spelt....17.5 | .... | 1.6 | .... | ..... | 23.5 Bu. | 10.12 |
| Barley .....37.0 | 34.1 | 7.0 | 2.7 | 272.1 | 20.1 Bu. | 9.76 |
| Flaxseed .....18.8 | 20.5 | 3.3 | 2.7 | 71.7 | 9.2 Bu. | 13.50 |
| Hay & forage.....70.7 | 83.9 | 21.7 | 20.3 | 50.2 | 1.6 Tons | 4.44 |
| Potatoes .....57.7 | 63.0 | 0.3 | 0.3 | 49.1 | 68.8 Bu. | 39.31 |

Of every hundred farms, 71 report hay and forage; 64 report corn; 58, oats; 58, potatoes; 51, wheat; 377, barley; 19, flaxseed, and 18, emmer and spelt. Except in the case of barley, the proportion of farmers reporting each of the specified crops for which complete data are given is smaller than it was ten years ago. The eight crops included in the above table cover about 77% of the improved land of the state. The most important relative increases in acreage related to barley, oats, flaxseed, and corn.[32] Fruit growing for local markets is

[31]For a good account of extensive wheat farming similar to that formerly practiced on a smaller scale in the northeastern corner of our area, see Coulter, J. L.: Industrial History of the Valley of the Red River of the North, Coll. of the State Hist. Soc. of N. Dak., Vol. III, pp. 529-672, 1910.

important in parts of the Black Hills having a long frostless season. Clover and Timonthy thrive at relatively high altitudes where much snow falls and are the chief forage crops there, as is alfalfa on irrigated land. Agriculture was commenced in 1876, the first season after the arrival of many prospectors in the Black Hills, in the valleys of Rapid and Spring creeks.[33]

The close relationship between crop yields and precipitation has been discussed in the chapter on climate and the relationship between yields and soil in the chapter on the bio-geography.

**Dry Farming.** Where the rainfall is not always sufficient for the growing of crops by the methods used in moist regions, considerable quantities of wheat, flax, and some other crops, are grown by the method called dry farming. Dry farming consists in preparing the soil so that almost all the moisture that falls is absorbed, and in hindering the subsequent evaporation of this moisture by a thin layer of dust on the surface, produced by repeated harrowing. Caked soil loses its water by evaporation much more rapidly than dust-covered soil. In the drier parts of South Dakota there are fifteen inches of rainfall a year on the average. Since cereals require at least nine inches for their development, it is obvious that from an area watered by rainfall and melting snow alone, very little can be allowed to escape if crops are to be grown. Under natural conditions nearly all of the fifteen inches that does not run off in streams (and much more than that amount, if it were available) would evaporate.

Differences in the yields from near-by fields seeded to the same crops in a dry year are due to (1) the nature of the soil (whether or not it cakes after showers), (2) the thoroughness of cultivation after heavy rains (the formation of the dust layer(, or (3) the time of planting, the preparation of the land, and the method of planting.

**Irrigation.** In dry regions the soil in many places is very rich in the mineral elements of plant food, as salts (potash, nitrates, and phosphates), accumulate near the surface, instead of being leached out and washed away by the run-off as may occur in well-drained parts of wet regions. Therefore, when the water supply is sufficient, crop yields are likely to be large in dry regions. These bounteous yields combined with the good markets for produce furnished by the mining population and the stock ranches are incentives to irrigation in parts of the state.

Most of the streams leaving the Black Hills were used early for irrigation, especially near Edgemont, Rapid City, and Spearfish. The first large project was that at Bellefourche, which was developed by the Federal government and completed in 1912. A tributary named Owl Creek, having a wide valley, was dammed and a large supply of water diverted from the Bellefourche River is stored there. From this reservoir, 100,000 acres are irrigated. Other projects irrigated and favorably reported on by the government experts are in the Grand River Valley, in the Little Missouri Valley, and along Moreau River. Lack of funds has prevented work on these projects to date.

Some of the private projects are (1) the irrigation of parts of Rapid River Valley (40,000 acres between Rapid City and the Chevenne River), (2) "the Cheyenne project," involving parts of Stanley County, and (3) irrigation by pumping, (a) along the Missouri River by the use of water power, and (b) along the Little Missouri Valley by power generated from the lignite deposits found in that part of the state. In

[32]Thirteenth Census Supplement for South Dakota, p. 625, (Washington, 1913); 1913 Year Book of the Department of Agriculture, (Washington, 1914).
[33]Tallent: loc. cit., p. 314.

1910[34] 500 farms, 0.6% of the farms of the state, were irrigated. The irrigated area, 63,248 acres, was 4% of the improved land in farms. Less than half the area in irrigation enterprises and less than one-fourth of the acreage of projects being developed was irrigated in 1909. Of the 63,248 acres irrigated, 60% were in individual or partnership enterprises, 21.5% in co-operative enterprises, 10% in commercial enterprises, and less than 9% under the United States Reclamation Service. Since the Bellefourche project was completed, the acreage under the Reclamation service alone exceeds greatly the total irrigated acreage of 1909. The total irrigated area of the state is now more than 210,000 acres. The sources of water used in 1909 were streams (75.4%), reservoirs (21.4%), wells (2.3%), springs (0.6%), and lakes (0.37%). The chief irrigated crops in order of value of product were alfalfa; "wild, salt or wheat grass;"[35] timothy and clover; oats; potatoes; wheat; orchard fruits; and corn.

(e) **Drainage.** When drained, wet lands are changed from breeding places of mosquitoes and disease to agricultural land of more than average value because in lowlands as in drylands, valuable salts and organic substances accumulate. As long as land not requiring drainage could be obtained cheaply, drainage was practiced little. With the rapid rise in land values since 1900, there has been a great increase in drainage. Thousands of short, open ditches have been dug to drain "lake beds," and a few large projects for the reclaiming of bottom lands have been carried out. Large areas in the flood-plains of the Missouri (between Vermilion and Yankton) Vermilion, Sioux, and Dakota rivers have been drained. An increase in the length of the Vermilion River, produced by the shifting of the Missouri River in 1881 decreased the gradient and transporting efficiency of the former stream and resulted in a higher water table and increased flooding of the lower part of the valley. The crooked stream has been replaced by a large nearly straight ditch eleven miles in length, with the result that the bottom lands for a dozen miles have been drained, at an average cost of $33 per acre.

### (2) Mining and Quarrying

Mining and quarrying are very subordinate to agriculture both in the numbers of persons employed, and in the value of the output. The minerals secured, the distribution of the mines, quarries, and undeveloped mineral resources, statistics of production, and other relevant matter are treated in chapter three. At this point certain supplementary matter is presented.

In 1909[36] more than 95% of the value of minerals produced (water excepted) came from "gold and silver deep mines," which employed about 95% of the 4,169 persons engaged in this industry, and took 90% of the 16,400 primary horse power used. There were ten sandstone (including quartzite) quarries, four of granite, two of gypsum, two of limestone, one of mica, one of tin, and three placer gold dredges. The value in 1910 of the produce of the minor branches of the industry was $311,477, in contrast to $6,120,970 from the "gold and silver deep mines."

### (3) Lumbering

The Black Hills are nearly covered with western yellow or bull pine, and lumbering has been carried on there ever since the region was populated by white men. The first sawmill was brought to Custer and put in operation in February, 1876.[37] Deadwood had two sawmills

[34] Supplement for S. Dak., U. S. Census, 1910, p. 657.
[35] See "The Wheat Grass Association," p. —.

and two planing mills in 1882.[38] Almost all of the lumber is consumed in the Black Hills region, as the timbering of the mine shafts requires large quantities. Two million feet of lumber are used annually in timbering the Homestead mine.[39] The Black Hills National Forest of almost 1,300,000 acres has been the scene of much good experimental work in lumbering and forest management by students of eastern schools of forestry and by government specialists. In the literature of American scientific forestry it holds almost as prominent a position as the Black Hills region does in the literature of geology.

In the valleys of the eastern part of the state there are groves of hard woods and cottonwoods, and on the uplands there are many groves which have been set out.[40] Although these trees are of great value as a source of supply for posts and firewood,[41] and as a protection from wind and sun, very little lumbering has been carried on recently due to the small size of the groves or of the trees.

Before the coming of the railroads many buildings were constructed of logs.[42] and sawmills and shingle mills were somewhat numerous. the first sawmill in the territory being erected at Sioux Falls in 1857.[43] The first machinery in Lincoln County was a shingle cutter put in operation on the Sioux River in 1868.[44] There were several steam sawmills in the Sioux and Missouri bottoms by 1870. Most of the sawmills had shingle mills attached, and lumber could be obtained at from $15.00 to $25.00 a thousand feet and shingles at $4.00 per thousand.[45] The census of 1885 recorded thirty-three sawmills in the Territory of Dakota, while the census of 1910 reports but three custom mills in the state.

### (4) Manufacturing

In South Dakota manufacturing has developed slowly, partly because of the proximity of the manufacturing centers at Sioux City, Iowa, and Minneapolis. For many years the manufacture of such products as flour and meal, lime, brooms, binder twine and butter has been carried on.

The first grist mill in Dakota was located on the Sioux River, three miles east of Elk Point, in 1869. There was only one in Clay County before 1870, but several were built there that year, and several in Union County.[46] The first flour mill in the western part of the state was erected at Deadwood in 1881.[47] In 1882 there were several flour or feed mills run by water power in this area; one at Bigstone, run by Whetstone Creek;[48] two at Canton, run by the Sioux;[49] the third largest flour mill in the world at Sioux Falls;[50] a grist mill at Olivet, driven by the Dakota River;[51] a feed mill near Springfield, driven by Emanuel

[38]U. S. Census: Supplement for S. Dak., pp. 676, 677,( Washington, 1913).
[37]Tallent: The Black Hills, p. 269.
[38]Polks Gazetteer for Minn. and Dak. for 1882, p. 952, (Detroit, 1882).
[39]Tallent: loc. cit., p. 513.
[40]The census of 1910 recorded that 2,600 farms (3.4% of all farms in the state) reported forest products in 1909, the total value being $257,000 in increase of 142% over 1899.
[41]Trees were planted at various points by 1866 (Foster: loc. cit., p. 91), and very extensively during the early 1880's under the stimulation of "the tree claim act."
[42]Armstrong, M. K.: History and Resources of Dakota, p. 33, (Yankton, 1866).
[43]Andreas, A. T.: Historical Atlas of Dakota, p. 136, (Chicago, 1884).
[44]Foster, J. S.: Outlines of the History of Dakota, p. 45, (Yankton, 1870).
[45]Ibid., p. 91.
[46]Ibid., p. 45.
[47]Andreas: loc. cit., p. 123.
[48]Polk's Gazetteer for 1882, p. 913.
[49]Ibid., p. 932.
[50]Ibid., p. 1096.
[51]Ibid., p. 1066.
[52]Ibid., p. 1105.

Creek;[52] and a flour mill and feed mill at Deadwood, run by Deadwood Creek.[53] In 1883 a mill was erected at Rapid City and run by Rapid Creek.[54] At the census of 1885 there were 85 flour and grist mills in Dakota, and in 1889 81 South Dakota towns had such mills.[55] In 1910 there were 91 such mills in the state, producing 34.7% of the total value of manufactures for the state.[56]

Dakota had twenty-six creameries, five broom factories, and sixteen breweries in 1887,[57] and twenty-five South Dakota towns had creameries in 1889.[58] In 1910 there were ninety-five creameries in the state producing 18% of the total of manufactures.[59] This great increase in the number of creameries between 1889 and 1910 is a manifestation of the diversification of agricultural practices already mentioned.

Plants for making plaster of Paris, stucco, and pressed brick, and for preserving meat, have been put in operation more recently. Pork packing is being undertaken on a large scale. A plant costing a half million dollars was completed in Sioux Falls in 1911, and another costing a million dollars was completed there in 1913. Sioux Falls is the South Dakota city most favorably located in respect to the section of the state in which most corn and hogs are grown.

The census reported in 1909, 5,226 persons engaged in manufacturing, adding $6,334,000 in value to raw material worth $11,476,000. Both these figures show an increase of nearly 46% per cent over the corresponding figures for 1904, the latter an increase of more than 100% over those of 1899, due partly to the rapid rise in prices during that decade.

The following table (20) gives the more important statistics concerning manufacturing in South Dakota for 1904 and 1909.[60]

[52]Ibid., p. 952.
[53]Tallent: loc. cit., p. 427.
[54]Hagerty: The State of South Dakota, p. 80, Aberdeen, 1889.
[55]U. S. Census: Supplement for S .Dak., p. 671, (Washington, 1913).
[56]McClure, P. F.: Resources of Dakota, p. 278, Aberdeen, 1887.
[57]Hagerty: loc. cit., p. 80.
[58]Census Supplement for S. Dak., p. 671.
[59]U. S. Census: Supplement for S. Dak., p. 672.

**Table 20—Manufacturing in South Dakota, 1904-1909.**

| Industry. | Number of establishments. | Wage Earners. | | Value of Products. | | Value Added by Manufacture. | | Percent of Increase. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Average number. | Percent distribution. | Amount. | Percent distribution. | Amount. | Percent distribution. | Value of products. | | Val. add. by manufacture | |
| | | | | | | | | 1904–1909 | 1899–1904 | 1904–1909 | 1899–1904 |
| All industries | 1,020 | 3,602 | 100.0 | $17,870,000 | 100.0 | $6,394,000 | 100.0 | 36.6 | 37.3 | 45.7 | 44.1 |
| Flour-mill and gristmill products | 95 | 285 | 7.9 | 6,208,000 | 34.7 | 872,000 | 13.6 | –4.8 | 103.1 | –24.9 | 121.6 |
| Butter, cheese, and condensed milk | 95 | 139 | 3.9 | 2,686,000 | 15.0 | 378,000 | 5.9 | 23.0 | 82.1 | 8.0 | 80.4 |
| Printing and publishing | 392 | 825 | 22.9 | 1,976,000 | 11.1 | 1,520,000 | 23.8 | 61.7 | 63.8 | 55.1 | 67.5 |
| Bread and other bakery products | 92 | 286 | 7.9 | 1,161,000 | 6.5 | 440,000 | 6.9 | 199.2 | 391.1 | 158.8 | 240.0 |
| Lumber and timber products | 58 | 451 | 12.5 | 945,000 | 5.3 | 596,000 | 9.3 | 150.7 | –23.8 | 112.9 | –7.6 |
| Liquors, malt | 4 | 76 | 2.1 | 606,000 | 3.4 | 375,000 | 5.9 | 56.2 | 38.6 | 56.9 | –1.2 |
| Tobacco manufactures | 59 | 203 | 5.6 | 454,000 | 2.5 | 290,000 | 4.5 | 38.4 | 66.5 | 44.3 | 57.0 |
| Cars and general shop construction and repairs by steam-railroad companies | 5 | 327 | 9.1 | 439,000 | 2.5 | 274,000 | 4.3 | 74.9 | 41.0 | 128.3 | 31.9 |
| Confectionery | 3 | 106 | 2.9 | 400,000 | 2.2 | 129,000 | 2.0 | 20.5 | ..... | - 8.5 | ..... |
| Gas, illuminating and heating | 17 | 108 | 3.0 | 278,000 | 1.6 | 158,000 | 2.5 | 87.8 | ..... | 58.0 | ..... |
| Artificial stone | 38 | 104 | 2.9 | 253,000 | 1.4 | 133,000 | 2.1 | 301.6 | ..... | 269.4 | ..... |
| Foundry and machine-shop products | 37 | 78 | 2.2 | 225,000 | 1.3 | 152,000 | 2.4 | 1.8 | ..... | –9.0 | ..... |
| Carriages and wagons and materials | 10 | 48 | 1.3 | 131,000 | 0.7 | 71,000 | 1.1 | 322.6 | –36.7 | 238.1 | –27.6 |
| Brick and tile | 12 | 54 | 1.5 | 103,000 | 0.6 | 72,000 | 1.1 | 22.6 | 82.6 | 12.5 | 93.9 |
| All other industries | 103 | 512 | 14.2 | 2,005,000 | 11.2 | 934,000 | 14.6 | ..... | ..... | ..... | ..... |

Nearly all the manufacturing done in South Dakota represents the attempt to supply local demands or to prepare the raw materials produced in the region for market elsewhere. The chief industries involve local agricultural products, the preceding table showing that about 51% of the total value of manufactured products is furnished by the milling, baking, and dairy industries, to which should be added much of the 11.2% accedited to "other industries," the most important of which is pork packing.

### (5) Commerce

Commerce is favored by an excess of some commodity or commodities in demand elsewhere, and facilities by which the surplus profitably may be transported to and sold in the areas in which it is wanted. Similarly, commerce is favored in any region where the population, desiring various articles not supplied in sufficient abundance in the locality, has the means and opportunity to import. In most cases such means are secured by the sale of other commodities of which an excess is produced. In many new areas there is importing before there is exporting, the imported goods being paid for out of wealth produced elsewhere and sent (loaned) to the area or bought by the new settlers. In years of short crops, importing is likely to decrease because of the reduced purchasing power of the population. However, in many instances imports are bought on credit and paid for after a favorable crop year.

South Dakota is a region of specialized production; a few commodities are produced in amounts far in excess of local demand, while many articles, including numerous necessities, are produced only in small quantities or not at all. The first factors mentioned above as favoring commerce therefore are operative. Transportation to and from the state is chiefly by railroads, there being very little transportation by water, none by electric lines (across the boundaries), and little (for any purpose) by roads. There are (1915) nearly 4,000 miles of railroad in the state; west of the Missouri River there are about 1,500 miles. In the eastern, more densely populated half of the state, except for portions of the Crow Creek Indian Reservation, there are few areas which are more than fifteen miles from a railroad station. West of the Missouri, the only areas farther than thirty-five miles from a railroad station are in southwestern Perkins County and southern Harding County.

The building of railroads has been facilitated in much of the state by the topography, and by certain features of the climate. The slight precipitation is an advantage, but the persistent and often high wind, the great range in temperature with the consequent large expansion and contraction of rails and other metal objects, the lack of fuel and in some places of suitable water for the engines, are handicaps to railroad operation. Another and serious problem is the great fluctuation in the volume of produce to be handled. The amount of grain exported from the zone served by a particular section of the railroad varies greatly from year to year, largely due to fluctuations in rainfall, while the "up-keep" cost of the railroad is almost as high in a year of small traffic as in one of large and profitable business.

Various phases of railroad building have been considered in the earlier parts of this chapter. Other phases will be treated in connection with the settlement of the area.

Electric lines are little developed in South Dakota, due chiefly to the relatively small population and to lack of local capital, but in part to the general lack of fuel supplies. The only interurban line is that between Deadwood and Lead (three miles apart); it is operated by hydro-electric power.

Water transportation at present is of significance chiefly to the farmers near the Missouri River in northeastern Gregory and northwestern Charles Mix counties. There grain is shipped by river steamers to the railroad at Chamberlain.

Wagon roads are numerous and usually of excellent quality, owing to the long season of slight precipitation and the topography, nearly level over large areas. The absence in much of the state of rock outcrops, sandy areas and trees also contribute to the good quality of roads. Chiefly for these reasons little work has been done on the roads. In most sections improvement has been limited to a small amount of grading to increase the run-off and accelerate drying after rains, and to the construction of culverts in the shallow depressions and of bridges across the few streams. In the western part of the state many of the less frequently traveled roads are little more than trails and lack bridges. The graveling or sanding of roads is discouraged in most parts of the state by insufficient local supplies of these materials and by the satisfactory character of the dirt roads during most of the year.

As in the early years of settlement, the leading exports are agricultural commodities and gold. The chief articles are wheat, flaxseed, barley, corn, oats, cattle, hogs, sheep, horses, poultry, eggs, butter, flour, packed meat, wool, and gold. The more important articles of import are manufactured goods, such as farm machinery, vehicles, wearing apparel, and fencing materials.

## II. HISTORICAL GEOGRAPHY OR THE EVOLUTION OF PRESENT CONDITIONS

### (A) Introductory: The Period Before General Settlement

More than a century and a half elapsed between the coming to South Dakota of its first whites and the establishment of permanent settlement in 1859; moreover, settlement did not become extensive until after 1878. The period before permanent settlement may be discussed under three heads, (1) Exploration, (2) The Fur Trade, and (3) River Commerce, as these activities were the chief ones of that period. The discussion of these activities will not be limited to the period before settlement, however, but will be continued to recent years.

### 1. THE GEOGRAPHY OF EXPLORATION

Situated in the interior of the continent and in the general latitude of the Great Lakes, and possessing fur-bearing animals, it was natural that the first white visitors to the South Dakota region should have been French fur traders. These dauntless but practical men went out from the French posts on the Great Lakes[61] progressively farther and farther as the fur-bearing animals nearer to the posts became depleted by the reckless methods practiced. The first white man to visit what now is South Dakota probably was Le Sueur in 1695.[62] It is certain that French traders regularly visited the Sioux Valley by 1700.[63] By 1743 they had advanced as far west as the Missouri, and planted a tablet near the site of Pierre claiming the soil for the king of France.[64] As early as 1755,[65] traders of the Hudson Bay Company followed up the Red River and down the Sioux and established a post near the site of

[61]Thwaites, R. G.: Mackinaw, Wisc. Hist. Coll., Vol. XIV, p. 1-16.
[62]Johnson, Willis F.: South Dakota, A Republic of Friends, p. 103, (Pierre, 1911).
[63]Robinson, Doane: A Brief History of S. Dakota, p. 24. (N. Y., 1905).
[64]Ibid., p. 215.
[65]Kerr, Robt. F.: President's Annual Address, S. Dak. Historical Society, S. D. Dept. of Hist. Coll., Vol. v., pp. 73-74, (Pierre, 1910).

Elk Point, close to the junction of the Sioux and Missouri valleys. They were not able, however, long to maintain this remote post in the enemy's territory.

The fur trade necessitated wide wanderings, the trader often visiting many Indian villages, or accompanying bands of Indians on their hunting trips. Therefore when the first scientific exploration commenced in 1804, fur traders and trappers had become more or less familiar with the Missouri River, several of its tributaries, and even with the Black Hills.[66] Few of the traders had the inclination or ability to write of their travels, so the earliest well known account concerning this area records the achievements of scientific explorers.

Crossed by the Missouri, the largest stream of the northern Great Plains, it was natural that this area should have been visited in the early days of water travel by parties en route for the Rockies and the Pacific Coast. The Lewis and Clark party (1804-06) was the first well known one to follow this route. Like many other and less well known parties,[67] it made only brief stops at points within the area of South Dakota, but it named various physical features and perpetuated the earlier names of others, and reports of the expedition contain interesting descriptions of Indians, the character and abundance of game,[68] and other matters. The first party to leave the river and travel across country was the Hunt expedition, en route in 1810 to Astoria near the mouth of the Columbia. This party crossed what are now Corson, Perkins and Harding counties.[69]

Such overland travel was facilitated in this region by the topography, the sparsity or absence of trees and brush, and the character of the herbaceous vegetation. Because of the abundance of nutritious grasses and naturally cured hay, parties were not hindered by lack of forage from making long trips at any season.

Northeastern South Dakota drains into Hudson Bay, and was under British influence until visited in 1820 by Major Longs' expedition, which compelled the removal of English flags and substituted American for British influence.[69a]

Dr. Nicollet, delegated by the Federal government to examine the geology and resources of the Territory of Iowa, visited in 1838-39 the eastern part of the area now known as South Dakota, then a part of Iowa, and mapped and named many of the lakes.[70] His glowing description of the Falls of the Sioux and of the surrounding area, coming to the attention of land speculators, led in 1856 to the first attempt at permanent settlement in the South Dakota area.[71]

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[66]Lewis and Clark record that a French trader named Valle claimed to have spent the winter of 1802-03 in the Black Hills (Robinson, Dr. DeLorme, "Editorial Notes," S. D. Dept. of Hist. Coll, Vol. 1, p. 97, 1902).

[67]Prince Maximilian of Wied made extensive studies chiefly in what now is N. Dak. in 1833. In 1832 and 1836 Catlin, the celebrated painter of Indians, spent several weeks in the vicinity of Ft. Pierre and of Pipestone quarry (Andreas: loc. cit., p. 90; Catlin: North American Indians). Audubon, the noted zoologist, studied birds and mammals along the Missouri in 1842.

[68]Andreas: Hist. Atlas of Dak., pp. 88-90, (Chicago, 1884), is a reprint of what the journal of the expedition contains concerning S. Dak. Coues Elliott: The Journal of the Lewis & Clark Expedition. New York.

[69]Chittenden, H. M.: Hist. of Amer. Fur Trade of the Far West, Vol. 1, pp. 182-199, (N. Y., 1904). Irving, Washington: "Astoria" contains a full account of the trip. Bradbury and Brackenridge, two skilled scientists, accompanied the Hunt party to the mouth of the Grand River and made many observations and collections of considerable scientific as well as general interest. Their accounts of their experiences are to be found in Thwaites' "Early Western Travels," (Bradbury: Travels in North America, Brackenridge: View of Louisiana).

[69a]Turner, F. J.: The Rose of the New West, p. 115 (New York).

[70]Extensive extracts from Nicollet's report on this area occur in the appendix of Bradford, Wm.: Notes on the Northwest, (N. Y., 1846).

[71]Bailey, D. R.: Hist. of Minnehaha County, S. D., p. 10 (Sioux Falls, 1899).

Shortly after the discovery of gold in California, there were urgent demands for roads, and if possible railroads, to bind the Far West with the East. During the 1850's much exploration was carried on at the instigation of the government with a view to finding practicable routes for such a railroad. The first widespread exploration in the South Dakota region was done in 1855-57 under the direction of General Warren by H. V. Hayden, subsequently director of the U. S. Geological Survey of the Territories. Hayden described the geological formations of the area and studied certain types of life.[72] Although he did not penetrate the Black Hills, he obtained a general idea of their structure. In part because of the Black Hills barrier,[73] it soon was recognized that there were better routes for a transcontinental railroad south of the South Dakota region. For years, this area was neglected, while more practical routes to the south and north were investigated.

The next exploration in this area resulted from persistent rumors[74] of the presence in the Black Hills of gold in paying quantities. Although the Indians, in 1868, had been promised permanent possession of this area, an expedition under General Custer was sent in 1874 from Fort Abraham Lincoln, near the site of Bismark, to explore and evaluate the Black Hills preliminary to their purchase from the Indians, should they prove to be of great value to the whites.[75] This expedition discovered gold, but the scientific members were not convinced of its abundance. After a more thorough examination of the area during the following summer the presence of hundreds of prospectors and of much gold was announced.[76] A great gold rush followed.

The underground water supply was one of the motives back of the later, and more detailed exploration of the state. Because of the character and structure of the underlying rocks, artesian waters are readily accessible in many parts of South Dakota, and because of the climate, and in many places the soil conditions, such waters are valuable. Therefore, the United States Geological Survey undertook the study of this resource, and assigned two geologists, Prof. J. E. Todd (already somewhat familiar with the conditions in the state because of work on the glacial deposits[77] and as State Geologist)[78] to the eastern half, and N. H. Darton to the Black Hills Region. In order to facilitate their work, many topographic maps were made. The geologic folios, water-supply papers and professional papers[79] issued later have proved of great value to well drillers, farmers and others, and

[72]Warren, G. K.: Prel. Report of Exploration in Neb. and Dak., 1855-57, (Washington, 1875), contains several reports by Hayden; also see Hayden's "Reports of the Geological Survey of the Territories," and Coues', Elliot: "Birds of the Northwest," (Washington, 1872).

[73]Although military explorations under Generals Warren and Raynolds had skirted the Black Hills during 1856-59, the first authenticated penetration of this area by whites was in 1874 by the Custer expedition. The routes taken by these and other expeditions are shown in O'Harra, C. C.: A history of the Early Exploration of the Black Hills Region, Bull. 4, S. D. Sch. of Mines, Plate 1, (Rapid City, 1904). Plates 2-8 are reproductions of early maps of that region.

[74]These rumors are treated more fully on following pages.

[75]Ludlow: Report of Reconnaisance to the Black Hills in 1874, (Washington, 1875.) N. H. Winchell, geologist, and G. B. Grinnell, zoologist, also submitted special reports of interest. Ludlow's report is reprinted in Rosen, P.: Pahasapa or the Black Hills, pp. 273-303, (St. Louis, 1899).

[76]Prof. Jenny with Henry Newton as geologist, set out for Ft. Cheyenne May 29th, 1875, under the military escort of Col. Dodge, (Tallent, A. D.: The Black Hills, p. 124, [St. Louis, 1899], Dodge, R. I.: The Black Hills, p. 10, N. Y., 1876.])

[77]Todd, J. E.: Bulletins 280 and 298 of the U. S. Geol. Survey.

[78]Bulletin I, 1894, of the state survey, a general report on the geology of the state probably did more to make widely known the geology of the state than any other publication. Bulletins 2-4 also are chiefly or partly by Prof. Todd. See chapter on geology and physiography, p. —.

[79]Listed in the chapter on geology.

"Darton's "Geology and Water Resources of South Dakota"[80] contains an excellent summary of these subjects.

### 2. The Geography of the Fur Trade

As noted in the previous section, the fur trade was established early in this region. It was of special importance between 1808 and 1837,[81] although nearly destroyed by the war of 1812-14.[82] Before 1808 bison were so numerous east and south of the South Dakota area that the fur trade of the "Sioux Country" was chiefly in the more valuable, less bulky, and more easily transported furs of the beaver, mink, and otter. These animals probably were originally less numerous here than in the more humid areas to the east, but in the latter they were killed off so rapidly that by 1800 there were more in parts of the South Dakota area than in many sections farther east. Furthermore, furs obtained from Dakota were (and are) more valuable than those secured in nearby states to the east and south.[83] The greater severity of most winters in South Dakota, the light snowfall of most years, and the persistence of the wind, are probable reasons for the difference.

During the height of the fur trade in this area, the hides of the bison were the chief skins secured. The abundance in early years of bison in this region was due in part to geographic conditions. The plains are grass-covered in response to climatic conditions, and this grass, especially the varities called "buffalo grass," is cured by dry weather in late summer. As there is little rain during the colder half-year to leach out the nutriment, most of it remains in the standing blades until the arrival of spring rains and new grass. Small snowfall, high rate of evaporation, and hard winds, permitted winter grazing on the naturally cured hay. The presence of alkali soils here and there throughout the area and of salt lakes in the western part,[84] made it unnecessary for the bison to migrate long distances for salt, as they had to do in some sections of their range.

The Indians of the Plains depended largely on the bison, and, where the latter were plantiful, the former were likely to be numerous. They supplied the fur traders with many skins and were so important in the fur trade of this region that the small-pox scourge of 1837, which almost depopulated several villages, perhaps was a potent influence in the decline of the fur trade.[85]

Many trading posts[86] were maintained at one time or another in

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[80]Darton, N. H.: The Geology and Water Resources of S. D., U. S. Geol. Survey, Water-supply paper 227, (Washington, 1909.)

[81]Chittenden, H. M.: The American Fur Trade of the Far West, Vol. III, (N. Y. 1902.)

[82]Kerr, Prof. Robt. F.: President's Ann. Address, S. D. Hist. Soc., S. D. Dept. of Hist., Coll. V, p. 76, 1910.

[83]So indicated in the price quotations from reputable St. Louis fur purchasing firms.

[84]Salt springs reported from what now is eastern N. D. are said to have been the source of salt manufactured by pioneers in the region during the late 1860's. (Batchelder Hist. and Resources of Dak., p.38, (Yankton, 1870.)

[85]Chittenden: Loc. cit., Vol. II, p. 626.

[86]The following list mainly from Chittenden of fur trading posts arranged in order up the Missouri River is of interest: (1) "Big Sioux Post," near the mouth of the Sioux River; not long maintained. (2) "Vermilion Post," near the mouth of the Vermilion River; (3) "Dickson's Post," near the site of Meckling. (4) "Rivere a Jacques Post," near the mouth of the Dakota River. For a time the Columbia Fur Company and the American Fur Company each maintained a post in this vicinity. (5) "Ponca Post," just above the mouth of the Niobrara River. (6) "Fort Mitchell," (1833-37), some where in what is now Gregory county. (7) "Handy's Post," near the site of Fort Randall. (8) "Traudeau's Post," or the "Pawnee House," (1796-97), below the mouth of the White River near the site of Wheeling. (9) "Fort Recovery," on American Island near Chamberlain. (10) "Fort Lookout," some ten miles above the site of Chamberlain, built shortly before 1822. (11) "Fort Kiowa," (1822-33), near

this region. Some were called forts, although the first fort garrisoned with troops was established in 1855, by which time the fur trade had nearly disappeared.

Nearly all, or quite all, of the fur posts were on streams; a large majority were on the Missouri River, and most of them were near the mouths of tributaries. This distribution reflects the importance of the water routes in transporting furs to market The exact location of many posts appears to have been influenced by groves, which furnished fuel. It is said that the chief post of the region, Fort Pierre,[87] at the mouth of the Teton River, owed its importance largely to its central location in the Sioux Country, its proximity to large Indian villages, and "the presence of a fine bottom a mile wide and six miles long."[88] The last doubtless was a minor influence, since there are many similar bottoms elsewhere.

The extermination of fur-bearing animals in most parts of this region probably came more promptly than in some other areas because of certain geographic conditions. In a region having frequent unfavorable seasons such as occur in the steppe, native mammals are less prolific than are closely related forms in regions of more uniform and less severe climatic conditions. Furthermore, the mamalian population of such a steppe region probably is less numerous than that of other areas. Even if the animals originally were as numerous and as prolific in the South Dakota region as elsewhere they doubtless would have been exterminated sooner than in certain other sections. In a grassy region of slight relief, large animals may be seen from a distance, as can streams, ponds, and other places favorable to semi-acquatic fur-bearing species, and thus the extermination of such animals is facilitated.

The fur trade was "about over" by 1855, when the American Fur Company[89] sold to the government the most important post, Fort Pierre, which became the first military post of the region. The price paid, $45,000[90] suggests the size of the post and the value of the fur trade in earlier years, when the post was built.

The slaughtering of bison for their skins continued to have some importance until the early 1870's, but by 1874 so few remained that the Custer Expedition saw none between the site of Bismark and the Black Hills, although it passed near what two years later was con-

Fort Lookout. (12) "Fort France," (1845-46), near the mouth of Medicine Creek. (13) "Loisell's Post" (1803-04), 35 miles below the site of Pierre. (14) "Fort George" (1842-46), some 14 miles above the preceeding site. (15) "Fort Tecumseh" (1822-32); (16) "Fort Pierre" (1832-55), both near the mouth of the Teton River and near the site of the city of Fort Pierre. (17) "Old Fort George," near the mouth of the Cheyenne River. (18) "Aricara Post," in the village of the Ree Indians near the mouth of the Grand River. "In addition scattered throughout the "Sioux Country" on both sides of the Missouri there were many subordinate posts or houses of the American Fur Company dependent on Fort Pierre. There were at least three or more in the valley of the James River (Riviere a Jacques). There was one at the forks of the Cheyenne and others on Cherry Creek and the White River." (Chittenden: loc. cit., Vol. III, pp. 952-955).

[87]Chittenden: loc. cit., Vol. III, p. 955.

[88]Ibid., p. 955.

[89]The Missouri River Fur Company was the first important company in this region. It was organized in St. Louis in 1808, and took over several posts, including the one a short distance above the site of Ft. Pierre. Fort Teton, near the mouth of the river of that name and near the site of Ft. Pierre, was established by a fur trader in 1817. In 1822 it was replaced by Fort Tecumseh built by the Columbia Fur Company. In 1828 the American Fur Company absorbed this company and became dominant in Dakota fur trade. Two other fur companies "The Northwestern" and "The Rocky Mountain had engaged in the fur trade of this region. King's Handbook of the United States, p. 789, (Buffalo, N. Y., 1894).

[90]Wilson, Frederick: Old Fort Pierre and its Neighbors. S. Dak. Dept. of Hist. Coll., Vol. 1, p. 279, (Pierre, 1900).

sidered to be the center of their rapidly diminishing range.[91] The disappearance of the bison was hastened greatly by the introduction in the middle 1860's of breach-loading rifles.

The fur trade as a leading industry had disappeared from this area before the establishment of permanent agricultural settlement and therefore influenced settlement little. All the posts were abandoned decades before towns were founded, although on the sites of some of them towns since have been built. This was true in the case of Fort Pierre, Flandreau and Vermilion.

Some of the smaller fur-bearing animals, especially the muskrat, mink, and skunk, increased in numbers after the decline of the regular fur trade, and their furs helped many pioneer farmers to become established.

### 3. RIVER COMMERCE

The Missouri always has been commercially the most important waterway of the area. Steamers never ventured on any other South Dakota river,[92] although there was a steamer on Big Stone Lake in 1881,[93] as there is today. Each of the other large streams doubtless floated the canoes of fur traders,[94] as they bear the few row boats and launches of today. However, no record of their use for floating logs or loaded or unloaded rafts or boats has come to light.

(a) **Before the Coming of the Steamboat,** the navigation of the Missouri does not appear to have been extensive, and it was associated chiefly with fur trade. The exploring parties which used the river as a highway in most cases accompanied a fleet of fur-trading boats. There is record, however, that shortly before 1870 a quantity of logs, cut from extensive groves a few miles up the river from Yankton, were floated down to a sawmill at that place.[95]

(b) **Steamboat Navigation.** The first steamboat, "The Yellowstone," to enter the confines of the present state of South Dakota did so in 1831. It visited Fort Teumsech, which was rechristened Fort Pierre in honor of Pierre Choteau, a distinguished passenger. The following summer this steamer ascended to Fort Union at the mouth of the Yellowstone River.[96] Henceforth, the American Fur Company sent one or two boats far up the river each summer until 1864.[97] The trip from St. Louis to the more remote forts and return usually required an entire summer. The quickest trip to Fort Union and return was made in 1850 by Captain LaBarge in 28 days.[98] The Missouri River long furnished the only route much traveled between Dakota and the East, and it was followed by many parties en route to the farther west.

The stream was of great importance to the fur trade; many posts were located along its banks, and most of the furs obtained before 1865 in the northern Great Plains and Rocky Mountains found their way to market down its channel. The total value of the fur trade of St. Louis in 1860 was $529,000, nearly all of which came down the Missouri River by boat,[99] from beyond the limits of South Dakota. After

[91]Dodge, R. I.: The Hunting Grounds of the Great West, map for 1876, (London, 1878).
[92]Brennan, John: Conditions and Resources of Southern Dak., p. 9, (Sioux City, 1872).
[93]Polk, R. L. & Co.: Gazetteer of Minn. and Dak. for 1881, p. 791. (Detroit, 1881).
[94]Lieut. Warren recorded that in 1855-56 canoes navigated the Dakota River (Hagerty: The Territory of Dakota, p. 9, Aberdeen, 1889).
[95]Foster, Jas. S.: Outlines of Hist. of Dak. and the Immigrants Guide, p. 54, (Yankton, 1870).
[96]Chittenden, H. M.: Hist. of the Early Steamboat Navigation on the Missouri River, Vol. 1, p. 139, (New York, 1906).
[97]Ibid., p. 139.
[98]Ibid., p. 133.

1862, when gold was discovered in what now is Idaho and Montana, there was a rush of prospectors, many of whom ascended the Missouri River and crossed southern Dakota, but influenced its development very little. The rush to these gold fields is reflected in the number of steamers that ascended the upper Missouri in the early 1860's. In 1860, 19 steamers passed Yankton on the way up the river; in 1861, 11; in 1862, 13; in 1863, 18; in 1864, 30; and in 1865, 39. Prior to 1864 there were only 4 arrivals of steamboats at Fort Benton, the head of navigation on the Missouri River; in 1866 and 1867 there were 70 arrivals. There was a sharp decline in the number of arrivals after 1867,[100] when the Union Pacific Railroad approached the gold field; In 1865, 1,000 passengers, 6,000 tons of merchandise, and 20 quartz mills were sent to Fort Benton; in 1867, 40 steamers carrying more than 12,000 tons of freight had passed Sioux City before June 1st.[102] In 1867, 71 steamers, averaging 260 tons each and carrying 16,655 tons of cargo, left St. Louis for Fort Benton and the upper Missouri.[103]

Steamboat navigation on the Missouri River was of great importance in the Indian Wars, which especially involved the period 1862-77. Supplies and men for the several forts along the Missouri River were conveyed chiefly by steamers. Various campaigns against the Indians, of which the most noted is the one of 1876 in which Custer was massacred,[104] depended on steamboats. During the decade 1870-1880 Sioux City was the great shipping point for the army in its work up the river, though after 1872, when the Northern Pacific Railroad reached Bismark, much freight started up-river from the latter place instead of from Sioux City.[105]

Steamboat navigation had relatively little influence on the settlement of most of the state, since agricultural settlement was not extensive until after the coming of the railroads had caused a speedy decline in river traffic. Sioux City was reached in 1868 by a railroad from the south (Council Bluffs) and from the east by two lines in 1870.[106] Vermilion[107] and Bismark were reached in 1872, Yankton in 1873, Chamberlain and Pierre in 1880.[108] Transportation on the Missouri always was uncertain and expensive, and Dakota farmers could not market their produce profitably in the settled sections to the east or south in competition with farmers situated nearer to those areas. No grain was shipped eastward from Yankton County until 1873, when the railroad was completed to Yankton.[109]

However, beef,[110] fodder,[111] grain, and other supplies for the up-river army posts, particularly Forts Randall and Sully, and for several Indian Agencies, were secured in part from settlers along the river in Bon-Homme, Yankton, Clay, and Union counties, and were transported in part by steamboat.[112] The mining camps of Montana are said to have received considerable produce from the same settlements during the late 1860's.[113]

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[99]Dixon, F. A.: A Traffic Hist. of the Mississippi River System, (Document 11 National Waterways Commission), p. 23, (Washington, 1909).
[100]Armstrong, M. K.: Early Empire Builders of the Great West, pp. 38, 51, (St. Paul, 1901).
[101]Chittenden: loc. cit., Vol. II, p. 273.
[102]Ibid., p. 275.
[103]Dixon: loc. cit., p. 54, quoted from Ex. Doc. 40th Cong. 3rd Sess., Vol. 2.
[104]Treated in detail in Tallent: The Black Hills, (St. Louis, 1889).
[105]Chittenden: loc. cit., Vol. II, p. 419.
[106]Batchelder: Hist. & Resources of Dakota, p. 43, (Yankton, 1870).
[107]Heston: loc. cit.
[108]Andreas: Historical Atlas of Dakota, p. 153, (Chicago, 1884).
[109]Ibid., p. 100.
[110]Foster: loc. cit., p. 68.
Hanson, Jos. Mills: The Conquest of the Missouri, p. 239, (Chicago, 1909).
[111]"Official Correspondence Relating to Fort Pierre," S. D. Dept. of Hist. Coll., Vol. I, pp. 383, 415, 1902.
[112]Foster: loc. cit., p. 68.
[113]Batchelder: loc. cit., pp. 30-31.

Although the steamers carried but little produce down-river from the Dakota area, they brought considerable quantities of supplies from the east. The first frame building at Yankton is said to have been brought from St. Louis in a steamer.[114] In 1870, after Sioux City had been reached by railroads, there was a steamer plying regularly between that place and Yankton which furnished "the cheapest and most expelitious means of transporting freight to Yankton."[115] With its help, average freight charges on boxed goods from Chicago to Yankton were only two dollars per hundred pounds in 1870.[116] Thus steamboat traffic had some influence on the agricultural development of the area under consideration. Steamers also influenced the development of certain towns, especially Yankton. "The traffic on the Missouri River, which was for years an important factor in Yankton's prosperity, as at one time as many as forty steamers did business at Yankton, at this time [1883] is very small."[117]

**Reasons for the Slight Development of River Commerce.** Steamboat traffic on the Missouri River had little influence on the industrial development of South Dakota, partly because of certain characteristics of the river. It is aggrading, swift, crooked, shifting, subject to marked fluctuations in volume and often very shallow at many points, obstructed by many sandbars, and frozen over for a considerable portion of the year. "The average velocity of its current has been estimated at three miles an hour, and this is greatly increased during the flood season in contracted portions of the river, frequently reaching five or six miles per hour, and forcing the most powerful steamers to use the towing lines.[118] As to fluctuations in volume: Although river steamers of three hundred tons burden,[119] having a draft of about four feet when loaded,[120] normally can navigate the river during the open season to the mouth of the Yellowstone, in the fall of 1862 the water was so low that an ordinary steamer could not reach Yankton, and had to unload its cargo five miles below, near the mouth of the Dakota River.[121] At other times the bottoms between Yankton and Sioux City are flooded to a width of ten miles in places, as in 1862,[122] 1881,[123] and in 1907, and lesser floods are expected each year. The magnitude and rapidity of the changes of channel are remarkable: "In many cases there is a shifting of two or three hundred yards in a few weeks into the bottom lands.'[124] The navigation of this section of the river usually is prevented for more than four months annually by ice.[125]

Therefore the steamboats could not successfully compete with the railroads, for several reasons which may be summarized as follows: (1) While the railroads can operate all the year, the river is closed by ice for a third of the year, when, therefore, the railroads have a monopoly. (2) As slow as was early rail transportation, it was far more rapid than that furnished by boats on the Missouri, which often could make but small progress against the current, and were in constant danger of

[114]Holly, F. C.: Our Heritage from the Dakotas, p. 84, (Chicago, 1890).
[115]Foster: loc. cit., p. 54.
[116]Ibid., p. 87.
[117]Andreas: loc. cit., p. 131.
[118]Howell, O. W. (Capt. of Engineers): Ex. Doc. House of Rep. 3rd Sess. 40th Congress, Cong. Series 1368, p. 622. Reprinted in the Collections of N. Dak. Hist. Soc. Vol. I, p. 380, 1906.
[119]Andreas: loc. cit., p. 85.
[120]McClure: loc. cit., p. 73.
[121]Andreas: loc. cit., p. 130. Many acres of crops were destroyed by this flood.
[122]Ibid., p. 130. The towns of Yankton and Vermilion were severely damaged, the property loss being set at $50,000 and $142,000 respectively. Ten persons lost their lives.
[123]Ibid., p. 133.
[124]Howell: loc. cit., p. 628.
[125]Andreas: loc. cit., p. 85.

running aground on bars. Because of the frequency of such occurrences boats could not approximately maintain a schedule. (3) The shallowness of the river at many points made necessary boats of small capacity, while the strength of the current required a relatively powerful engine with corresponding fuel supply. This inflexibility is in contrast to trains of lengths varying with the needs. (4) The losses involved in steamboat navigation were much greater than those to which rail transportation is subject. The muddy water, of necessity used by the boats, caused many boilers to explode; snags were numerous and severely damaged many boats; others, in running with the current, were so thoroughly grounded on bars as to be removable only at so great an expense that in many cases they were abandoned until a rise in the river, or permanently. (5) The heavy expenses resulting in part from the high wages secured by the pilots, who must be highly skilled, and the heavy charges demanded by insurance companies, were severe handicaps to river commerce. (6) the ever-shifting channel, together with banks of silt, made the problem of wharfage a serious one in most places. The approach to the docking place of the boats was, in many cases,. made very difficult by bayous, sand, "blow-outs," "gumbo," or steep slopes. The approach to railroad depots in nearly every case is enormously easier.[126]

For the foregoing reasons, steamboats now have little significance on the Missouri. In 1906 there were only ten steamboats on the Missouri River above Sioux City, and most of these were above Bismark.[127] The only steamboat traffic of moment in South Dakota is the taking of grain from various points in the northern parts of Charles Mix and Gregory counties to the railroad at Chamberlain, which has been favored for decades in possessing a fairly stable water front,. the best for three or four hundred miles.[128]

## (B) THE SETTLEMENT OF THE STATE

### 1. Causes for the Late Settlement of this Area

The first attempt at permanent settlement was made in 1856 near the falls of the Sioux. From 1857 to 1862 many homes were established in the Sioux Valley, but all were abandoned between 1863 and 1865 on account of the Indian scare and a permanent settlement was not established until July, 1859, at Yankton. The population of Southern Dakota probably did not exceed 2,000 in 1865 or 12,000 in 1870, by which date Iowa had more than a million people (1,115,000), and in 1878 it probably was less than 60,000. The causes for the delayed settlement of this area are in part geographic: (1) As long as lands more desirable in respect to location, climate, or resources were available, there was little demand for lands in the area of South Dakota. (2) The government followed the policy of not attempting to secure title to Indian lands until the demand for them was urgent. As a result, the Indians claimed all of what now is South Dakota until 1851 when a small strip east of the Sioux River was ceded. The next tract obtained from the Indians, consisting of much of eastern South Dakota, was declared open to settlement in July, 1859. The next large tract included the Black Hills, and was opened in 1877; the next was opened in 1889 (Fig. 36.) Until the Federal government obtained title to the land, it attempted, with a good deal of success, to keep would-be-settlers out. (3) Until the railroad net was fairly dense, transportation to distant markets was very expensive

[126]For a discussion of causes for the decline of water transportation see Barrows, Harlan H.: The Geog. of the Middle Illinois Valley, Bull. 15, Ill. Geol. Surv., pp. 100-102. (Urbana, 1910); Chittenden: Hist. of the Early Steamboat Navigation of the Missouri River, Vol. II, Chap. 39. (New York, 1904).

[127]Dixon: loc. cit., p. 55.

[128]Polk's Gazetteer of Minn. and Dak. for 1882, p. 941.

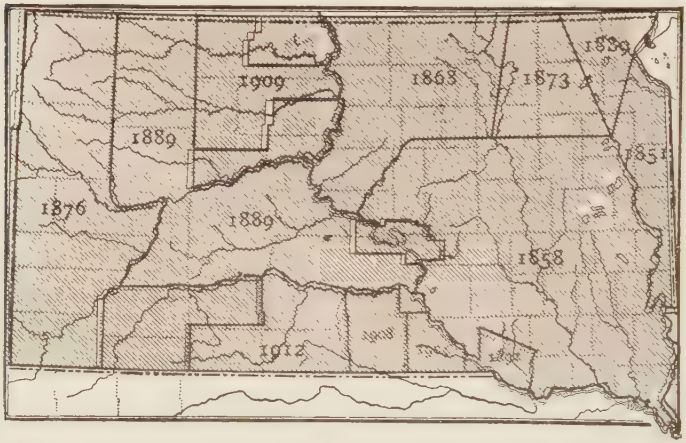


Fig. 36. Map Showing the Progressive Reduction of Indian Reservations in South Dakota.

Fig. 37. Historical Map of South Dakota.

rom most of the areas, there being only one stream navigable by steam-oats and that, for various reasons noted, quite unsatisfactory. (4) roughts and the visitations of devastating hords of grasshoppers, gave he region a bad reputation in some quarters and at some periods. 5) The Kansas-Nebraska bill accelerated the settlement of those areas, specially Kansas, and tended to retard the settlement of other sections f the frontier.[129]

## (2) THE SETTLEMENT BEFORE 1876

In 1856, the white population of the area now included in South akota appears to have consisted chiefly of a few traders and trappers, ost of them of French extraction,[130] of whom a majority had Indian ives.[131] There also were some soldiers, and the steamers on the Mis-ouri River carried a few transients. The first white woman to visit this rea, the wife of a steamboat captain, came in 1847.[132]

In 1851 the Santee Sioux Indians, by the Treaty of Traverse de ioux,.[133] relinquished their lands situated to the east of the Big Sioux iver (Fig. 36) and settlement was made legal in a small area, near ioux Falls, but within the present confines of South Dakota. In 1856 party from Dubuque, Iowa, attempted to found a settlement at the falls f the Sioux, but was driven away by Indians. It returned the follow-ng summer. Early in 1857 the government erected Fort Randall on he Missouri River (in what is now Gregory County) and undertook to eep the Indians out of deeded territory and to prevent settlers from ccupying lands still in the reservation.[134]

(a) **The Beginnings of Settlement.** In May, 1857, a party of land peculators from St. Paul, Minnesota, laid out four towns in the Big ioux Valley.[135] Two of them (Sioux Falls and Flandreau) still exist, lthough they were abandoned from 1862 to 1865 because of the fear f Indians, while Medary was burned and permanently deserted in uly, 1856,[136] as was Emineza. The falls of the Sioux, enthusiastically escribed by Nicollet, determined the location of the town of Sioux 'alls,[137] while the Big Bend of the Sioux River and a trading post ocated there in 1822 determined the location of Flandreau.[138]

During 1858 there was considerable immigration to the Sioux Falls egion, the first woman settler coming in the summer and the first amily with children in the fall.[139] That year the Yankton Sioux In-ians sold for $1,600,000[140] most of the tract between the Sioux and lissouri rivers (Fig. 36). On July 10th, 1859, the Indians were removed rom this area and the reservation was declared opened. Some hun-reds of prospective settlers, who had encamped on the Nebraska side f the Missouri River awaiting the opening, immediately crossed over and ithin the next few weeks the towns of Yankton, Meckling, and Vermilion ere laid out. Elk Point was founded shortly after[141] These towns ere all near the Missouri River, the chief highway at that time: Yank-

[129]Hale, E. E.: Kanzas & Nebraska, p. 234, (Boston, 1854).
[130]Andreas, T. A.: Historical Atlas of Dak., p. 135, (Chicago, 1884).
[131]Robinson, Doane: A Brief History of S. Dak., p. 216, (New York, 905).
[132]Ibid., p. 218.
[133]Foster, J. S.: Outline of Hist. of Dak. Terr., p. 7, (Yankton, 1870).
[134]Blackburn, W. M.: Historical Sketch of N. & S. Dak., S. Dak. Dept. of ist. Coll., Vol. 1, p. 47, 1902; Robinson, Dr. De Lorme: Editorial Notes n above sketch, Ibid., p. 116.
[135]Armstrong, M. K.: Early Empire Builders of the Great West, p. 27, St. Paul, 1901).
[136]Andreas: loc. cit., p. 96.
[137]Bailey: loc. cit., p. 216.
[138]Robinson, De L.: loc. cit., p. 728.
[139]Andreas: loc. cit., p. 96.
[140]Robinson, Doane: loc. cit., p. 219.
[141]Foster: loc. cit., pp. 8, 46.

ton near the mouth of the Dakota River on a low terrace being eroded by the Missouri River and hence affording fairly good wharfage; Meckling near the river in a large area of unforested plain between Vermilion and Yankton; Vermilion at the foot of the bluffs at the mouth of the Vermilion River; and Elk Point on the flood-plain at the junction of the Sioux and Missouri valleys, and not far from those streams. During 1859, 1860, and 1861 there were good crops and rather rapid settlement [142] As a result, there was considerable agitation for territorial government, this area having been left without government when Minnesota was admitted in 1858.

Late in 1861 Dakota Territory was created by act of Congress, and in 1862 Yankton was selected by the first governor as the capital. A census taken in June, 1862, just after the organization of the territory, revealed a population of 2,402,[143] distributed as follows: Sioux Falls, 40; Clay and Union counties, 696; Yankton County, 287; Bonhomme County, 163;[144] and the balance chiefly in the Red River Valley in what is now North Dakota.

Four counties were organized in 1862, Union, Clay, Yankton, and Bonhomme, all on the eastern border of the Territory. Two additional counties were organized before 1871 in the Sioux Valley: Lincoln County (1867), just north of Union and Clay counties, and Minnehaha County (1868), containing Sioux Falls, just north of Lincoln County.

In 1862 Congress passed the Homestead Act. This statute, later of great significance in the settlement of the state, had little immediate effect because of the competition of lands farther east, the lack of cheap transportation facilities between this area and the settled portions to the east, and especially the fear of Indian uprisings.

(b) **Hard Times.** In August, 1862, two citizens were murdered by Indians near Sioux Falls,[145] Closely following massacres in Iowa and Minnesota in which several hundred whites were killed,[146] produced a panic among the frontier settlers of Dakota. "So many returned to the Eastern states, that the area was almost depopulated."[147] More than three-fourths of the settlers fled, according to one writer,[148] and another stated that only three hundred remained in the area,[149] The Sioux Valley was entirely deserted from September, 1862, until May, 1865, when Fort Dakota was erected at Sioux Falls. It was kept well manned for four years.[150] It was not until 1866 that farmers returned to the Sioux Valley.[151] In Bonhomme, the westernmost county the settlements began in 1860, and comprising 200 persons in September, 1862, were deserted; eight years later the population of the county was only 500.[152] The panic stricken settlers who did not leave the territory gathered in a stockade at Yankton.[153] Experiencing no more trouble from the Indians that fall or winter, a few returned to Vermilion, Elk Point, or Jefferson and built stockades at those points.[154] "In the spring and summer of 1863 more settlers were murdered in Dakota than before or since."[155] In 1864 the Indians continued espe

[142]Foster: loc. cit., p. 10.
[143]Armstrong: loc. cit., p. 32.
[144]Andreas: loc. cit., p. 96.
[145]Foster: loc. cit., p. 13· Andreas: loc. cit p. 162.
[146]Heston: Hist. & Activities of the People of Dakota, Encyl. Americana
[147]Blackburn, W. M.: Hist. Sketch of Dak., S. D. Dept. of Hist. Coll., Vol 1, p. 52.
[148]Andreas: loc. cit., p. 99.
[149]Armstrong: Early Empire Builders, loc. cit., p. 35.
[150]Blackburn: loc. cit., p. 52; Bailey: Hist. of Minnehaha County, p. 31
[151]Ibid., p. 67; Foster: loc. cit., p. 76.
[152]Foster: loc. cit., p. 67.
[153]Andreas: loc. cit., p. 99.
[154]Robinson, D.: Outlines of S. Dak. Hist., S. D. Dept. of Hist. Coll., Vol II, p. 75, 1904.
[155]Foster: loc. cit., p. 17.

cially troublesome, there was a severe drought and a devastating visit of grasshoppers, and as a result most of the few settlers left Dakota.[156] For these reasons very little was done from 1862 to 1865 "toward extending the settlements or following agricultural pursuits, except the raising of stock," for which there was a good market at the posts and agencies.[158]

The following data illustrate the stagnation during this period: The population of the Sioux Valley in 1868 was said to have been less than it was ten years previous.[159] The population of Lincoln County on Jan. 1st. 1868, was placed at 33 persons;[160] two and a half years later it had 712. Although Elk Point was incorporated in 1862, it first had a store in 1866.[161]

The Indian troubles in this section ended in 1865[162] when Fort Dakota was erected at Sioux Falls,[163] but the influx of settlers continued to be slow for a time, partly because of the very unfavorable reputation given the area as a result of the drought and grasshoppers of 1864. The worst effects of these blights had been witnessed by several regiments of Iowa volunteers, members of the second expedition against the Indians.[164] The discouraged settlers doubtless circulated unfavorable reports also.

(c) **The First Boom.** With the close of the Civil War and the growth of a feeling of security from the Indians, stimulated by forts and several military expenditions, there was increased interest in the frontier. Interest in the South Dakota section developed for the most part after 1868, at which date Sioux City was connected with the East by rail.[165] With 1869 what may be called the First Dakota Boom set in. It lasted until 1873, and was blasted by the devastations of grasshoppers in that year and the year following. The boom of 1869-73 was due to (1) good crops in this area, (2) the approach or arrival of railroads with a resulting great improvement in transportation facilities, and (3) the rapid occupation of lands in Iowa. The following quotations suggest the influence of good crops on the settlement: "The year 1867 was a prosperous one for Dakota. * * * crops were generally good."[166] "The rush of immigration during 1868 was so great that at the close of the year the population of the Territory was estimated at 12,000."[167] "The crop of 1868 had been uniformly good, and the citizens of the territory in writing to their eastern friends had given such glowing descriptions of the country that early in the spring of 1869 evidence was given of an unusually large accession to the population of Dakota by immigration."[168]

Previous to 1869 no organized effort, except that of the New York Colony, had been made to bring settlers to Dakota. In July, 1869, a

[156]Armstrong, M. K.: Hist. and Resources of Dak., p. 47, (Yankton, 1868).
[157]Foster: loc. cit., p. 14.
[158]Ibid., p. 68.
[159]Andreas: loc. cit., p. 96.
[160]Andreas: loc. cit., p. 136.
[160]Census of 1870.
[161]Polk's Gazetteer for 1881: loc. cit., (Detroit, 1881).
[162]Foster: loc. cit., p. 26.
[163]Blackburn: loc. cit., p. 52.
[164]Foster: loc. cit., p. 23.
[165]Chicago was connected by rail with the Atlantic Coast in 1853. The Mississippi River west of Chicago was reached by 1855. Sioux City, was connected by rail with Chicago in 1868 by a line up of the Missouri Valley from Council Bluffs, and in 1870 by two lines directly across the state. Sioux City became the terminus of the railroad because it was favorably located on the outside of a great bend of the Missouri River on well-drained ground and on the east side of the Big Sioux River, which was not bridged easily, and was not crossed until 1872.
[166]Foster: loc. cit., p. 33.
[167]Andreas: loc. cit., p. 100.
[168]Foster: loc. cit., p. 40.

Bohemian colony was organized and several hundred settlers came.[170] Large groups of Norwegians came during the same year. It is said that 800 of them left Sioux City for Dakota on June 3, 1869.[169] The New York Colony was organized in Syracuse, New York, in 1863, principally through the efforts of Jas. S. Foster and Chas. Van Epps. Mr. Foster was sent west in August, 1863, and after visiting Iowa, Dakota, Nebraska, Kansas, and Missouri, he returned and reported in favor of Dakota. A special train was chartered to Marshalltown, Iowa, the terminus of the line and the railroad station nearest to Dakota. Adult members of the association were furnished tickets for the trip for $15.00, the freight was carried the entire distance for $2.05 per hundred pounds. Of the one hundred families which started from New York, forty settled in Iowa. Many of the sixty families which settled in Dakota became disheartened by the drought and grasshoppers of the first summer, and left. Six years later, in 1870, only thirty families remained. They were distributed along the Missouri Valley, mostly near Yankton,[171]

In 1873, a colony of Russian Mennonites settled in Bonhomme County.[172] Groups of acquainted families had made "colony settlements" at earlier dates. For instance, a "colony" of Norwegians from Mankato, Minnesota, settled in Bonhomme County in 1860,[173] and more than one hundred families of Scotch from Canada settled near Scotland in the same county during 1872-74.[174]

The influx of settlers was promoted in this period not only by land agents, colony organizers, and railroads, but by local improvements in transportation facilities. Ferries had been established at various points. One across the Dakota River on the route between Sioux City and Fort Randall was installed for the special benefit of the troops.[175] Early settlers of several counties, including Union, Clay, and Yankton, also kept ferries on the larger streams along the route between Sioux City and Yankton.[176] These streams were bridged by government appropriation in 1868, a notable improvement.[177] Shortly after the arrival of the railroad in Sioux City, a daily stage to Yankton was established, and in the same season Sioux Falls and Yankton were united by a mail stage.[178]

Transportation was facilitated somewhat by three government roads. In 1865 Congress had appropriated $85,000 for the opening of three wagon roads through Dakota Territory to the distant mines in the Rockies. One was along the Missouri Valley from Sioux City to the Mouth of the Cheyenne River; another was built up the Cheyenne to its forks;[179] a third, the Nobles road, followed approximately the southern boundaries of Brookings and Kingsbury counties to what now is the northwestern corner of Sanborn County, and thence southwestward to the big bend of the Missouri River.[180] None of these roads reached the Rocky Mountains.

In 1870 that part of Dakota Territory now in South Dakota had a population of 11,776.[181] Before the beginning of the Great Boom

[169]Sioux City Times, June 3, 1869.
[170]Foster: loc. cit., p. 42.
[171]Foster: loc. cit. pp. 19-21.
[172]Andreas: loc. cit., p. 146.
[173]Ibid., p. 146.
[174]Ibid., p. 146.
[175]Ibid., p. 146.
[176]Armstrong: Hist. of Dak., p. 35.
[177]Foster: loc. cit., p. 35
[178]Ibid., p. 36.
[179]Blackburn: loc. cit., p. 56; Foster: loc. cit., p. 25.
[180]S. D. Dept. of Hist. Coll., Vol. VI, pp. 183-201.
[181]The 13th Census of the U. S., Abstract for S. Dak., p. 568, (Washington, 1913).

(1878-86) only two small parts of the area had a population of two or more per square mile. The southeastern corner (the lower Missouri and the lower Sioux valleys) had this density after 1869, and the Black Hills after 1876. The population in the former section was found chiefly on the flood-plains, with a large majority in the Missouri Valley. This suggests the significance of the Missouri River as a waterway. The relative proximity to more densely populated areas in the east and south was also of importance. Between 1868 and 1872, when a railroad was extended into Dakota, Sioux City, Iowa, served as a market for such produce as was shipped eastward out of the region, and, as the depot from which imports were received. Sioux City had a population of 4,000 in 1870.[182] The population of the Dakota counties in 1870 reflects these influences. Union County, in the southeastern corner of the Territory and in part within four miles of Sioux City, had a population of 3,507; Lincoln, the county next to the north and more distant from both railroad and navigable river, had a population of 712; while Minnehaha, the next county to the north and on the frontier of settlement, had only 355. Clay County, to the west of Union, but on the Missouri River, had a population of 2,621; the next county, containing the capital, had 2,097; while Bonhomme County, the next up the valley and on that frontier, had only 608.

(3) **The Gold of the Black Hills and Its Influence on Settlement**

The presence of gold in the Black Hills was rumored more than three decades before its discovery in 1874. Gold probably was discovered in 1834 by a party all but one of whom were killed by the Indians. This man left a tablet telling of the fate of his comrades, but was not heard of thereafter. Nuggets of gold said to have been taken from this party were given to traders and to Father DeSmet soon after, and Indian traditions support the legend on the tablet.[183] Several publications issued before 1874 treating of the resources of Dakota mention the gold of the Black Hills as one of the inducements to settle in Dakota. Even before the existence of gold in the Black Hills was established with certainty these reports had some influence on settlement. In 1872 a private expedition was prevented by a military force from exploring the Hills.[184] and settled in the eastern half of the territory.[185]

The expedition of 1874 under General Custer, which discovered gold, was the first to give a written account of the interior of the Black Hills. The Black Hills region belonged to the Indians until Feb. 28, 1877, although they are said never to have frequented the Hills proper,[186] and until nearly that date they made many efforts to keep white civilians out.[187] Until November, 1875, the United States army also endeavored to prevent trespassing on this Indian reservation.[188] The goods of many offenders were burned, and the leaders of a number of expeditions were imprisoned.[189] However, the lure of gold was so powerful that in spite of military opposition, Indian resistance, and many natural hardships, there were many who attempted to acquire wealth in the supposed marvellously rich gold-field guarded so zealously. The first party of prospectors that reached the vicinity of the place where

[182] Foster: loc. cit., p. 104.
[183] Tallent, A. D.: The Black Hills, p. 10, (St. Louis, 1899).
[184] Ibid., p. 5. An expedition had been organized in 1868 to explore the Hills but it was broken up by the government, Foster, J. S.: Outlines of Hist. of Dak., p. 35, (Yankton, 1870).
[185] Tallent: loc. cit., p. 193.
[186] Ibid., p. 111.
[187] Ibid., pp. 296-308. Even as early as 1857 they zealously guarded this region and prevented an expedition under General Warren from penetrating the Hills. Ibid., p. 4.
[188] Ibid., p. 7. The treaty of 1868 had guaranteed this region to the Indians for all time.
[189] Ibd., pp. 86, 130-138.

gold was first found, arrived from Sioux City, December 24, 1874, after a seventy-eight day journey.[190] At present the trip can be made by train in little more than fourteen hours. Two members of this first party returned to civilization with some gold late in February, 1875, and spread the "gold fever."[191]

During the summer of 1875 there was a considerable influx of prospectors and the government had the area re-examined by scientists. enough gold and other minerals were found[192] to warrant the purchase of this area from the Indians, but they refused to consider its sale until all the prospectors had left. General Crook, in charge of the troops engaged in attempting to keep out intruders, invited the prospectors to assemble, and after explaining to them the demands of the Indians, persuaded nearly all of them to leave the region for the time being.[193] When the conference with the Indians proved unsuccessful, almost all official hindrance ceased,[194] and soon there was a rush of settlers. Eleven thousand persons arrived between November, 1875, and March 1st, 1876.[195] Most of the new arrivals flocked to Custer, laid out near the original discovery, which became a city of at least 6,000 persons and 1,400 buildings by the latter date.[196]

The scarcity of gold, the insufficiency of water for washing the gravel, the appropriation of more promising localities in the southern Hills, and the partial exhaustion of the placers there, encouraged widespread prospecting with the result that gold was discovered elsewhere. In June, 1876, Deadwood Gulch, seventy-five miles north of Custer, was found to contain rich placers, and there was a rush to that locality.[197] Custer was almost deserted, and remained an insignificant place for nearly a decade.[198] Deadwood, in the valley of that name, promptly became a city of importance, acquiring a population of 7,000 almost immediately. After the discovery of large bodies of ore in the locality, it took on a more permanent character.[199] Other cities grew up near various deep-mines; Lead, by far the largest city in the Black Hills, is an example.

The settlement of other parts of the area under consideration was affected in various ways by the presence of gold in the Black Hills. This was true after 1878 as well as before, and the following discussion is not limited to the earlier years. (1) The most direct effect of the gold was that the miners, the speculators, and most of the people supported directly or indirectly by them, furnished a market for various commodities. In response to the high prices[200] which then prevailed in the mining towns, which were separated from railroads by many miles of poor trails infested with robbers and Indians, farming and stock rais-

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[190]Ibid., pp. 20-60. An account of this trip by the authoress, one of the members of the party.

[191]Ibid., p. 86.

[192]Rosen, P.: Pahasapa or the Black Hills, pp. 597-611, is a reprint of the report rendered the government by Jenny, the leader of the party.

[193]Tallent: loc. cit., p. 132.

[194]Ibid., p. 139.

[195]Ibid., p. 140.

[196]Ibid., p. 140.

[197]Holley, F. C.: Our Legacy from the Dakotas, p. 100, (Chicago, 1890).

[198]Three years after being a city of from "6,000-10,000" it had fewer than 50 inhabitants; Polk's Gazetteer for 1882, loc. cit., p. 950.

[199]Deadwood, situated in what is almost a canyon, was nearly demolished by flood in 1879, but was promptly rebuilt. It was almost destroyed in 1883 by fire, and never recovered first place in population, which Lead has held since. It still is the commercial center of the Hills.

[200]A meal cost seventy-five cents to a dollar in Deadwood in 1876 and potatoes twelve to fifteen cents per pound (Curley, E. A.: The True History of the Black Hills, p. 80, [Chicago, 1876]). Flour sold as high as $60.00 per hundred pounds. A dozen cats sold at $10.00 apiece, (Tallent: loc. cit., p. 352). Miners and mechanics received from $5.00 to $7.00 per day for their services, (Ibid., p. 353).

ing in the region both reached significant proportions before the area was purchased from the Indians.[201]

The more favorably located farmers in the eastern part of the Territory also for several years sold produce to this population, and freighted large quantities of supplies from the railroad termini to the Black Hills during the period 1880-85. From 1876 until 1880, in which year Chamberlain, Pierre and Dickinson (North Dakota)[202] were reached by rail, the chief freight and stage lines had their railroad termini at Cheyenne,[203] or at Bismark, but from 1880 until 1885, when a railroad approached the Hills from the south, Pierre was the most important shipping point thence.[204] In 1883 upwards of 26,000,000 pounds of freight and 5,000 passengers were carried between Pierre and the Black Hills, by the two chief transportation companies[205] by means of twenty-four four-horse coaches (run ten per week each way), 1,400 wagons, more than 3,000 oxen, 850 mules, and 400 horses.[206] The total amount of freight received in the Black Hills after 1877 is said to have been at least forty million pounds a year.[207] A large part of the livestock used in transporting this freight was reared near-by, and the companies secured many other things from the agriculturists of the region. In addition to the transporting done by regular companies, goods were carried to the Black Hills from Pierre by "farmer outfits." During the winter considerable sums were earned in this way by many farmers of Hughes and neighboring counties.

(2) Another way in which the gold of the Black Hills influenced the settlement of neighboring areas was by attracting thousands of young men, many of whom, after a stay in the mining camps or towns, went on ranches or farms, or entered business in one or another of the towns seen on the way to the Hills. Indeed, a large majority of the "old timers" in the western part of the state came to the region during the gold rush. During recent years many foreigners, brought from eastern cities to work in the Homestake mine, have established agricultural settlements near the Hills. There are several colonies of Finns in Harding County whose founders got their start in the mines of the Black Hills. Many persons who set out for the Black Hills during the excitement over the discoveries of gold were attracted by opportunities for farming or business in the eastern part of the state, and remained there instead of making the costly trip to the gold-field.

(3) The presence of gold, the excitement its discovery created, the numerous encounters with the Indians, and especially the exciting times in the mining camps, particularly Deadwood, were described in numerous newspapers, magazines, pamphlets and books,[208] as well as by word

[201]Curley: loc. cit., pp. 20-40; Tallent: loc. cit., pp. 296-308.

[202]Hanson, Jos. Mills: The Conquest of the Missouri, p. 385, (Chicago, 1909).

[203]United States mail service to the Black Hills was not established until after the area was ceded by the Indians, March 1, 1877. During the preceding year a celebrated "pony post" between the Hills and Cheyenne carried letters at 25 cents each. (Tallent: loc. cit., p. 194-6; Holley: loc. cit., p. 100).

[204]Rosen: loc. cit., p. 117; Andreas: loc. cit., p. 124.

[205]For a very readable account of a trip from Pierre to Deadwood in 1883 see Maudet-Grancy: Colonels and Cowboys, (London, 1886). The fare charged at that time was $20 and it cost 10 cents per pound for baggage (p. 34).

[206]Andreas: loc. cit., p. 124.

[207]Ibid., p. 125.

[208]Tallent, D. A.: The Black Hills, (St. Louis, 1899), gives excellent descriptions of events in the early days of this region as experienced by the capable authoress, a resident of the area from the first, or as related by other pioneers. There are dozens of pretensious books on the history of the Black Hills. Next to Tallent, Rosen, P.: Pahasapa or The Black Hills, (St. Louis, 1899), perhaps is the most worthy. An excellent account, with county histories, will be found in that compendium of historical lore on Dakota, Andreas, A. T.: Historical Atlas of Dakota, (Chicago, 1884).

of mouth. These descriptions advertised this region widely, making Dakota a familiar name throughout the country and paving the way for the Great Dakota Boom which followed.

(4) The opening of deep gold mines and the development of other mineral resources which gave promise of furnishing permanent employment for many workers with consequent great and persistent demand for commerce, led railroad companies to contemplate the extension of their lines to this reigon. It was on a tour of inspection of proposed routes to the Black Hills that the president of the Chicago and Northwestern Railway became so impressed with the great possibilities of the area east of the Missouri River that he resolved to try an experiment in railroad building. He believed that if railroads were built in the Dakota prairies, settlers would flock in, provide a great deal of traffic, and so make the railroad investment profitable. This plan received the approval of the directors of the company, and also was adopted promptly by its great rival, the Chicago, Milwaukee and St. Paul Railroad Company. As a result, the Great Dakota Boom was made possible.[209]

### 4. The Great Dakota Boom

During the period 1879-1886 much of the territory of Dakota was settled. What a few years before had been an almost uninhabited expanse of prairie, became a fairly populous farming region, soon to be admitted as a state. Probably more people moved into the region to make farm homes during any two years of the boom than during the twenty years which followed its collapse. The increase in population of 1907 over 1887 (perhaps 60,000) is less than the increase by birth during this period, supplemented by a relatively small immigration, mainly to cities and towns.

Because of the importance of this boom in the settlement of the state, it is desirable to consider in some detail the influences, especially the geographic influences, which produced, extended, and terminated it. Of primary significance was the fact that for several years the rainfall came at such times and in such amounts as to permit abundant yields. During several consecutive seasons abnormally heavy yields were secured in spite of careless preparation of the ground, the use of seed poorly adapted to the area, and lack of knowledge (or disregard of it) as to when and how to plant, what crops to sow, and how to care for them. Had the years 1879-86 been as dry as the eight years which preceded and the eight which followed, no such boom could have taken place, and had they been as dry as the period 1889-96, most attempts at settlement would have failed. (See chapter V, Climate, p. 50.)

A climatic factor of less, though considerable, importance in producing the boom was the "hard winter" of 1880-81 in the Northwest. The October blizzard, and the very heavy snowfall which accumulated during the winter, were unfavorable to the influx in some respects, since they brought hardships to many unprepared homesteaders and tended to give the area a bad reputation so far as its winters were concerned. In other respects this exceptional winter promoted settlement. The ground still was unfrozen when the first snow came, and because of the great depth of the snow (averaging more than ten feet, it is claimed)[210] it remained unfrozen, or was frozen to a slight depth only over large areas. In March and April, when the snow melted, the soil and subsoil were saturated with water, and each of the thousands of undrained depressions of the prairie contained more or less water. Many

[209]Robinson, Doane: A Brief Hist. of S. Dak., p. 157, (New York, 1905).

[210]Robinson, Doane: A Brief Hist. of S. Dak., p. 164, (New York, 1905). This average doubtless applies only to the more eastern part of the area, the part in which there were most settlers at this time.

of them contained water for several years thereafter. As a result of this unique snow-fall, the water-table was higher for years, and some claim that this influenced crops for several seasons, and there was a progressive decrease in yields during several years after 1881.[211] Certain it is that this snow, by creating thousands of ponds and lakes, suggested a humid climate, a condition highly attractive to prospective settlers.

Aside from the relative abundant precipitation of this period, the extension of railroads throughout most of the area was of great importance in starting and maintaining the boom. Without good transportation facilities, or the expectation of their being provided soon, the boom could not have taken place. Even though wheat, corn, and other crops of similar bulk and value yielded exceptionally well, farming would not be profitable if the produce has to be hauled many miles to market. Development is discouraged also where necessary articles are very costly. Because of the lack of timber in much of this region, materials for buildings and fences, and other bulky and heavy articles, cost so much after being wagoned long distances, that most improvements were discouraged. Only with the help of much fencing and many buildings can a region support a fairly dense human population by rearing stock that can be driven long distances to market.

Before the boom, the area now included in South Dakota was served very inadequately both by railroads and by river transportation. In 1873 a railroad reached Yankton, the capital, by way of the Missouri Valley, and the same year one was built west a few miles to Lake Kampeska, near the site of Watertown. There were no settlers in the latter region, and the line was extended to this, the westernmost point on the Sioux River, primarily to secure the building company the largest possible grant of land, as Congress had granted a land subsidy based on the mileage for a line to be built across Minnesota to the Sioux River.[212] In 1874 a prairie fire destroyed the bridges and culverts along the western part of this line, and that section was useless until these structures were replaced in 1879.[213] Sioux Falls, the second largest city of southern Dakota, had no railroad nearer than Worthington, Minnesota, sixty-eight miles distant,[214] until late in 1878. Then a line was built up the Sioux Valley, connecting Sioux Falls with Sioux City and the East.[215]

There were several results of the insufficiency of markets, due chiefly to the few transportation facilities. Most of the few pioneers found in the area not served by the Yankton-Sioux City line (and many of those in that region before that line was built), as well as the more remotely located and the poorer homesteaders of subsequent years, "had as their main employment the holding down of a claim"[216] in the hope that railroads soon would appear and make their land valuable. Most of their buildings were made chiefly of prairie sod, even the roofs, in many cases, consisnting of poles and sod. In case a grove of large trees was near, as was the condition along most of the Missouri Valley, logs were used in building. On the prairie "buffalo chips," hay, corn-cobs, brush were available, and even ear corn at times, were burned for fuel. Little fencing was done, and that chiefly with local

[211] Finley, J. P.: Certain Climatic Features of the Two Dakotas, p. 25, (Washington, 1890).
[212] Andreas, T. D.: Historical Atlas of Dak., p. 158, (Chicago, 1884).
[213] Heston, F. W.: South Dakota, Encyclopedia Americana.
[214] Holley, F. Q.: Our Heritage from the Dacotahs, p. 39, (Chicago, 1890).
[215] Andreas: loc. cit., p. 165.
[216] Blackburn, W. M.: Hist. Sketch of N. & S. Dak., S. Dak. Dept. of Hist. Coll., Vol. I, p. 49.

materials.[217] Only a small portion of the land was tilled, and wild game and fruits contributed largely to the larder of the settler. The money received from the sale of furs secured in winter appreciably increased the income, but until railroads came a large proportion of the homesteaders depended in part on earnings secured in other regions.

In view of the hardships arising from the lack of cheap, expeditious and reliable transportation, the following quotations appear not to involve much exaggeration: "The whistle of the locomotive would be the sweetest music a resident of the broad prairies could hear, and the mere rumor that a party of railroad surveyors had been seen in a particular locality, was enough to fill the heart of every settler with joy and cause visions of town-site and county-seat speculations to color with all the beauteous hues of the rainbow, his dreams at night"[218] Possibly some of the remote pioneers thought "every obstacle would flee as if by magic at the sound of the locomotive."[219]

The great importance of the railroad to the settlement of this area is emphasized in the following quotations: "As a direct consequence of progress in railroad construction the increase of the territory in population and wealth has been phenomenal in the history of the country."[220] "The greatest factor in the upbuilding of Dakota, next to her vast expanse of productive lands, has been the railroad. * * * Gradually the fine agricultural lands and immense stock ranges would, no doubt, have been occupied; but without the railroad it would have required a century to accomplish what has been done in five years under its powerful influence."[221]

The railroad companies supplied more than transportation facilities. They issued descriptive pamphlets to the new-comer, containing suggestions of value, and in many cases the railroad company "was explorer, carrier, provider, thinker, heart, soul, and intellect."[222]

A third potent factor in the rapid settlement of Dakota during this period was the earlier occupation of much of the more desirable land elsewhere, especially to the east. By 1879 there was available in the eastern states little free land as desirable for farming as eastern Dakota. The fertility of the soil of this area had been established by "bumper crops," the topography in most places was more even than in most other sections, and, of great significance in creating an agricultural boom, the land was ready for the plow, it not being necessary to clear it from trees, stumps, brush or stones as in most of the unoccupied areas to the east.

A fourth factor, not entirely geographic, was that the clean, nearly level fields of the prairies of Dakota had distinct advantages over the rugged, stony, or stumpy areas so widespread to the east, in the use of most labor-saving farm machinery. The self-binding reaper and the improved grain separator recently had made large-scale farming possible in regions like Dakota.

In addition to the four factors, chiefly geographic, discussed above, at least two others, chiefly non-geographic, were of importance in connection with the great influx at this time, and they may be remembered briefly. (1) As considerable capital was required for constructing railroads and buildings, breaking sod, and caring for crops, it was of im-

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[217]See footnote on p. —— concerning wooden fences in the Missouri Valley. The groves of trees scattered widely throughout the area contributed most of the fence posts until a relatively recent date (p. —).

[218]1st Ann. Rept. of the Board of R. R. Commissioners of the Ter. of Dak., p. 8, (Fargo, 1886).

[219]Holley: loc. cit., p. 342.

[220]Andreas: loc. cit., p. 98.

[221]Ibid., p. 100.

[222]Kerr, E. F.: President's Address to S. D. Hist. Soc., S. D. Dept. of Hist. Coll., Vol. V, p. 81, 1910.

portance that at this time the nation was in a prosperous condition. The effects of the panic of 1873 largely had been overcome, and the abolition of the fiat currency (insufficiently supported greenbacks) had improved greatly the country's credit abroad, with the result that there was a great inflow of foreign capital during this period. (2) Hard spring wheats are grown in the region much more successfully than soft winter wheat. The invention, shortly before this time, of a milling process by which they could be used in making flour as good as that made from soft wheats greatly increased the price of hard wheat and made wheat-raising much more profitable here than it otherwise would have been This increased demand for land, and stimulated settlement.

The following table contains further facts of interest concerning the Great Boom. It gives for various counties the dates (1) of the first settlement, (2) the second settlement, (3) by which settlers became fairly numerous, (4) of county organization, (5) of the first railroad, and (6) when most or all the area was occupied.

**Table 21. Historical Data Concerning the Counties**[223]

| County | First Settlement Made | Second Settlement Made | Settlers Fairly Numerous | County Organized | First Railroad Arrived | Settlement Became General |
|---|---|---|---|---|---|---|
| Aurora | 1879 | .... | 1880 | 1881 | 1880 | 1880 |
| Beadle | 1879 | 1879 | 1880 | 1880 | 1880 | 1880 |
| Bennett | .... | .... | 1912 | 1912 | .... | 1912 |
| BonHomme | 1859 | 1859 | 1869 | 1862 | 1881 | 1872 |
| Brookings | 1857 | 1869 | 1872 | 1871 | 1880 | 1879 |
| Brown | 1880 | 1880 | 1881 | 1880 | 1881 | 1881 |
| Brule | 1873 | 1879 | 1880 | 1875 | 1880 | 1881 |
| Buffalo | 1881 | 1881 | 1881 | 1871 | .... | .... |
| Butts | 1877 | 1877 | 1883 | 1883 | 1889 | 1909 |
| Campbell | 1877 | 1882 | 1883 | 1883 | 1899 | 1883 |
| Charles Mix | 1878 | 1878 | 1879 | 1879 | .... | 1882 |
| Clark | 1879 | 1879 | .... | 1880 | 1882 | 1882 |
| Clay | 1859 | 1859 | 1866 | 1862 | 1872 | 1870 |
| Codington | 1878 | 1878 | 1878 | 1878 | 1873–79 | 1878 |
| Corson | 1876 | 1906 | 1906 | 1910 | 1907 | 1907 |
| Custer | 1875 | 1876 | 1876 | 1877 | 1885 | 1877 |
| Davison | 1873 | 1873 | 1874 | 1873 | 1880 | 1879 |
| Day | 1876 | 1877 | 1880 | 1881 | 1880 | 1880 |
| Deuel | 1872 | 1877 | 1878 | 1878 | 1873–77 | 1878 |
| Dewey | 1889 | 1907 | 1909 | 1910 | 1910 | 1910 |
| Douglas | 1878 | 1882 | 1882 | 1882 | 1889 | 1882 |
| Edmunds | 1882 | 1882 | 1883 | 1883 | 1886 | 1883 |
| Fall River | 1876 | 1877 | 1885 | 1883 | 1885 | 1886 |
| Faulk | 1882 | 1882 | 1883 | 1883 | 1884 | 1884 |
| Grant | 1874 | 1878 | 1878 | 1878 | 1880 | 1878 |
| Gregory | 1857 | 1894 | 1904 | 1898 | 1904 | 1904 |
| Haakon | .... | .... | 1906 | 1814 | 1907 | 1907 |
| Hamlin | 1877 | 1878 | 1878 | 1878 | 1880 | 1878 |
| Hand | 1880 | .... | 1880 | 1882 | 1880 | 1881 |
| Hanson | 1872 | 1873 | 1880 | 1871 | 1880 | 1880 |
| Harding | 1880 | .... | 1909 | 1909 | .... | 1911 |
| Hughes | 1880 | 1880 | 1880 | 1880 | 1880 | 1882 |
| Hutchinson | 1869 | .... | 1875 | 1871 | 1879 | 1880 |
| Hyde | 1880 | 1880 | 1880 | 1884 | 1880 | 1882 |
| Jackson | .... | .... | 1906 | 1914 | 1907 | 1907 |
| Jerauld | 1876 | .... | 1879 | 1883 | 1902 | 1883 |
| Kingsbury | 1873 | 1877 | 1879 | 1879 | 1880 | 1882 |
| Lake | 1870 | .... | 1875 | 1873 | 1881 | 1878 |
| Lawrence | 1876 | 1876 | 1876 | 1877 | 1890 | 1876 |
| Lincoln | 1866 | 1877 | 1878 | 1867 | 1878 | 1878 |
| Lyman | 1890 | .... | 1890 | 1893 | 1907 | 1905 |

[223]The date of organization was secured from the thirteenth census, except in the case of the two counties formed since then. The other data were gathered from many sources, more from Andreas' Historical Atlas of Dakota than from any other single source. The table has been submitted to Doane Robinson, Secretary of the S. Dakota Historical Society, who made a number of additions and corrections.

| County | First Settlement Made | Second Settlement Made | Settlers Fairly Numerous | County Organized | First Railroad Arrived | Settlement Became General |
|---|---|---|---|---|---|---|
| McCook | 1871 | 1871 | 1879 | 1879 | 1880 | 1879 |
| McPherson | 1882 | 1882 | 1883 | 1883 | 1887 | 1885 |
| Marshall | 1864 | .... | 1881 | 1885 | 1884 | 1883 |
| Meade | 1877 | 1877 | 1877 | 1889 | 1887 | 1909 |
| Mellette | .... | .... | 1910 | 1911 | .... | 1912 |
| Miner | .... | .... | 1880 | 1880 | 1883 | 1880 |
| Minnehaha | 1857 | 1857 | 1866 | 1868 | 1878 | 1879 |
| Moody | 1857 | 1869 | 1873 | 1873 | 1879 | 1878 |
| Pennington | 1876 | 1876 | 1877 | 1877 | 1886 | 1877–07 |
| Perkins | .... | .... | 1908 | 1909 | 1909 | 1909 |
| Potter | 1883 | 1883 | 1883 | 1883 | 1887 | 1883 |
| Roberts | 1881 | 1883 | 1883 | 1883 | 1884 | 1892 |
| Sanborn | 1875 | 1875 | 1876 | 1883 | 1883 | 1881 |
| Shannon | .... | .... | 1913 | 1913 | .... | 1913 |
| Spink | 1879 | 1879 | 1879 | 1879 | 1882 | 1881 |
| Stanley | 1875 | 1890 | 1880 | 1889 | 1907 | 1906 |
| Sully | 1880 | 1883 | 1883 | 1883 | 1910 | 1883 |
| Tripp | 1904 | 1909 | 1909 | 1909 | 1909 | 1909 |
| Turner | 1869 | 1871 | 1871 | 1871 | 1880 | 1879 |
| Union | 1859 | 1859 | 1859 | 1862 | 1872 | 1870 |
| Walworth | 1877 | 1883 | 1884 | 1883 | 1888 | 1885 |
| Yankton | 1859 | 1859 | 1859 | 1862 | 1873 | 1873 |
| Ziebach | 1909 | 1909 | 1909 | 1911 | 1910 | 1909 |

It will be observed from this table that most of the region not then included in Indian reservations first was entered by settlers between 1870 aod 1880. In several cases where the first settlement was several years before 1880, settlers did not soon become numerous. Settlers were numerous before 1878 only in those few counties (1) containing parts of the lower Missouri and lower Sioux flood-plains, (2) adjoining this tier, or (3) in the Black Hills. It will be noted that some counties were organized with but few settlers. Seventeen counties were organized before 1878, while thirty-two were formed during the next seven years. The fourteen counties organized since 1885 are all west of the Missouri River, most of them having been carved from Indian reservations soon after they were opened to settlement. Before 1880, railroads had been built in only seven counties; five of them were on the southeastern periphery of the Territory. By 1888 all but three or four of the forty-five counties east of the Missouri River and four of the Black Hills counties had at least one railroad. In most counties, settlement was general and railroads arrived at about the same date.

The following sketch of railroad extension is especially unsatsifactory for the period before 1884. Commencing with 1885 an annual report was prepared by a territorial board of railroad commissioners. For a discussion of the factors which influenced the precise location of railroad lines, see p. 113.

Before 1878 only three counties had railroads in operation, the total length of the latter being less than sixty miles. August 1st, 1878, Elk Point and Sioux Falls were connected by rail.[224] During 1879 this line was extended forty miles to Flandreau and the fifth county entered. In 1880 more than 380 miles of line were built; two lines crossed the eastern part of the Territory to the Missouri River at Pierre and Chamberlain, both being reached in November.[225] These lines open up a wide strip of country. The Missouri River was reached at a third point, Running Water, in 1881,[226] and in that year the line which reached Milbank in 1880[227] was extended westward to Aberdeen. By the close

[224]Andreas: loc. cit., p. 165. About thirty-five miles of this line is on the Dakota side of the Sioux River and the rest on the Iowa side.
[225]Ibid., p. 153.
[226]Rosen: loc. cit., p. 417.
[227]Andreas: loc. cit., p. 172.

of 1881 the Chicago, Milwaukee and St. Paul Company had 680 miles in operation in this area and the Chicago and Northwestern 445 miles.[228] During 1882 there seems to have been relatively little building. Madison was reached by the Southern Minnesota division of the Chicago, Milwaukee and St. Paul, and Redfield also received a railroad from the east. During 1883 the line up the Dakota Valley from Yankton to Aberdeen was completed[229] and the east-west line to Madison was extended beyond Howard. Before June 30th, 1884, this line was extended to Woonsocket. Probably there were other extensions during this year. During the year ending June 30th, 1885, 145 miles of line were completed in Dakota and the total mileage of the two more important southern Dakota companies was brought to 795 for the Chicago, Milwaukee and St. Paul and 576 for the Chicago and Northwestern.[230] During the next year, 679 miles were completed; in the succeeding year, 716;[231] while during the next fiscal year only 114 miles were built.[232] During the calendar year 1886 more than a thousand miles were completed in Dakota. A considerable part of this was on the divide between the Sioux and Dakota rivers, but extensive sections were on the western Coteau, and some in the Black Hills. There was little railroad building in southern Dakota between 1888 and 1905. In 1890 the mileage was 2,610; in 1905, only 3,067. As reflected in the following table of land entries and as shown by other data summarized in Table 21, active settlement did not take place in some sections until one, two, or three years after the coming of railroads. This was conspicuously the case west of the Dakota Valley. In many counties the establishment of train service coincided with widespread settlement.[233] During the height of the boom (1882-85), railroads were not built fast enough to serve the rapidly growing settlements, and much land far from completed lines was filed on. Some such land was not served effectively by railroads for several years.

**Table 22 Land Filed on in Dakota, July 1, 1874, to June 30, 1889. in Acres[234]**

| | | | | | |
|---|---|---|---|---|---|
| 1874, | 206,000 | 1880, | 2,269,000 | 1885, | 4,548,000 |
| 1875, | 392,000 | 1881, | 2,673,000 | 1886, | 3,075,000 |
| 1877, | 213,000 | 1882, | 4,360,000 | 1887, | 2,076,000 |
| 1878, | 1,378,000 | 1883, | 7,317,000 | 1888, | 1,881,000 |
| 1879, | 1,657,000 | 1884, | 11,083,000 | 1889, | 2,383,000 |

The increase in land claims in the last year indicated in the above table is due to the opening during that year of the Sioux reservation comprising the area now in Lyman and Stanley counties.

The magnitude of the Dakota Boom is indicated strikingly by the

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[228] Polk's Gazetteer for 1882, p. 906.

[229] Andreas: loc. cit., p. 146.

[230] First Annual Rept. of the Board of R. R. Commissioners, p. 24, (Fargo, 1886).

[231] McClure, P. F.: Resources of Dak., p. 245, (Aberdeen, 1887).

[232] Fourth Annual Rept. of Board of R. R. Commissioners. More than half of this was the line between Watertown and Huron.

[233] "Language cannot exaggerate the rapidity with which these communities are built up. You may stand ankle deep in the short grass of the uninhabited wilderness; next month a mixed train will glide over the waste and stop at some point where the railroad has decided to locate a town. Men, women and children will jump out of the cars and their chattels will be tumbled out after them. From that moment the building begins. The courage and faith of these pioneers are something extraordinary. Their spirit seems to rise above all obstacles;" Blackburn, W. M.: Historical Sketch of N. and S. Dak., S. D. Dept. of Hist. Coll., Vol. I, pp. 73-74, written 1893, published 1901.

[234] The figures for 1875 to 1887 are from McClure: loc. cit., pp. 276-79 for 1888 from Hagerty: Dictionary of Dak., p. 10, and his "Terr. of Dak." The figure for 1883 as given by Andreas: loc. cit., p. 98, is 10,000 larger than that given above.

following comparisons: During the first five years of the territorial government (1862-66) only 100,000 acres were filed on,[235] and before August 1, 1870, less than 500,000 acres had been taken.[236] Nearly two-fifths of the entire acreage filed on in the United States in the year ending June 30, 1883, was in Dakota, where nearly twice as much land (7½ million acres) was filed on, as in Minnesota, Nebraska, and Kansas combined.[237] During the decade ending June 30, 1889, nearly forty-two million acres, or nearly half the area of Dakota, was filed on. Probably more than three-fifths of this immense area was in southern Dakota, which then had about two-thirds of the population of Dakota. By 1887 no free land remained in twenty-two counties of southern Dakota and nine others had an average of only 2,500 acres each,[238] most of which was then under water.

The growth in population during this period shows most clearly the magnitude of the immigration. Fairly reliable data are obtainable only for 1880 and 1885, in which years a federal and territorial census, respectively, was taken. The following table 23 indicates the ppoulation by counties for these years, together with the increase of 1885 over 1880:

**Table 23. Population, 1880 and 1885, According to Censuses of Those Years**

| County | 1885 | 1880 | Increase Over 1880 |
|---|---|---|---|
| Aurora | 5,950 | 69 | 5,881 |
| Beadle | 10,318 | 1,290 | 9,028 |
| BonHomme | 7,449 | 5,446 | 1,981 |
| Brookings | 8,228 | 4,965 | 3,323 |
| Brown | 12,241 | 353 | 11,888 |
| Brule | 7,524 | 238 | 7,286 |
| Butte | 1,081 | ..... | 1,081 |
| Campbell | 1,199 | 50 | 1,149 |
| Charles Mix | 4,022 | 407 | 3,615 |
| Clark | 4,892 | 114 | 4,778 |
| Clay | 6,201 | 5,001 | 1,200 |
| Codington | 5,648 | 2,156 | 3,492 |
| Custer | 1,292 | 995 | 297 |
| Davison | 5,940 | 1,256 | 2,684 |
| Day | 5,601 | 97 | 5,504 |
| Desmet | 76 | ..... | 76 |
| Deuel | 4,403 | 2,302 | 2,101 |
| Douglas | 3,801 | 6 | 3,795 |
| Edmunds | 2,422 | ..... | 2,422 |
| Ewing | 50 | ..... | 50 |
| Fall River | 472 | ..... | 472 |
| Faulk | 3,120 | 4 | 3,116 |
| Grant | 6,793 | 3,010 | 3,783 |
| Hamlin | 3,757 | 693 | 3,064 |
| Hand | 7,057 | 153 | 6,904 |
| Hanson | 3,933 | 1,303 | 2,632 |
| Harding | 43 | ..... | 43 |
| Hughes | 5,268 | 268 | 5,000 |
| Hutchinson | 9,006 | 5,573 | 3,433 |
| Hyde | 2,175 | ..... | 2,173 |
| Jerauld | 3,458 | ..... | 3,458 |
| Kingsbury | 7,345 | 1,102 | 6,243 |
| Lake | 5,432 | 2,657 | 2,775 |
| Lawrence | 10,326 | 13,248 | 2,922 |
| Lincoln | 7,598 | 5,896 | 1,702 |
| McCook | 5,641 | 1,283 | 4,358 |
| McPherson | 1,422 | ..... | 1,422 |
| Marshall | 2,187 | ..... | 2,187 |
| Miner | 4,928 | 363 | 4,565 |
| Minnehaha | 13,857 | 8,251 | 5,606 |
| Moody | 5,189 | 3,915 | 1,242 |
| Pennington | 3,224 | 2,244 | 980 |
| Potter | 2,336 | ..... | 2,336 |
| Roberts | 2,154 | ..... | 2,154 |

[235]Armstrong, M. K.: Early Empire Builders, p. 47, (St. Paul, 1904).
[236]Batchelder, Sec.: Hist. of Dak., p. 45, (Yankton, 1870).
[237]Andreas: loc. cit., p. 98.
[238]McClure: loc. cit.

**Table—Population 1880 and 1885 according to censuses of those years.**

| County | 1885 | 1880 | Increase Over 1880 |
|---|---|---|---|
| Sanborn | 4,106 | ..... | 4,106 |
| Spink | 10,446 | 477 | 9,969 |
| Stanley | 653 | 793 | 140 |
| Sully | 3,233 | 296 | 2,937 |
| Turner | 8,282 | 5,320 | 2,962 |
| Union | 8,017 | 6,813 | 1,204 |
| Walworth | 1,412 | 46 | 1,366 |
| Yankton | 9,404 | 8,390 | 1,014 |
| Unnamed strip | 1,055 | ..... | 1,055 |

The total population of the area now in South Dakota, according to the census of 1880, was 98,268, including 16,487 in the Black Hills. In 1885 it was 263,411, of whom only 14,842 were in the Black Hills.[239] The increase in the eastern part of the area (the rest was in Indian reservations) therefore was 166,788 in five years. In 1890, 328,808 persons were recorded in the state, of which number 32,559 were in the Black Hills region. The enumeration for 1880 was made after the great influx was well started, while that for 1890 was taken after there had been a great exodus due to two or more crop failures and to many disappointments on the part of town builders and speculators. Therefore it is impossible to give accurately the total influx to this area during the boom in question. An approximate statement is possible: The population reported by the ninth census (1870) was less than 12,000. The number was estimated to have doubled by the winter of 1872.[240] In 1875 the Territory of Dakota was estimated to have 50,000 people,[241] of whom nearly 35,000 probably were in what now is South Dakota. The increase between 1875 and 1878 was slow, except in the Black Hills, and it is likely that the eastern part of the region had less than 50,000 when the boom started in 1878. The rapid influx continued for some time after the enumeration of 1885. The Bureau of Immigration estimated that the increase for 1886 was over 85,000, and for the first half of 1887 about 45,000.[242] Assuming that the increase for the last seven months of 1887 was at a corresponding rate, the population of the area would have been more than 440,000 in June, 1887—an increase of more than 750% in about nine years.

Striking as the influx to Dakota during this period is when considered in its larger aspects, as above, it may be illustrated even more vividly by the consideration of smaller units. Beadle county in 1880 had only thirty-seven acres in farms; in 1885, it had 135,834.[243] Huron was platted by the railroad company in May, 1880. The first train arrived June 25. The population in the spring of 1884 was estimated at 3000. The improvements made during 1883 cost $450,000.[244] Brown county in 1880 had only 468 acres in farms; by 1885 it had 248,346,[245] and a population of more than 12,000. Early in 1880 it had contained fewer than 100 persons.[246] Previous to June, 1881, the site of Aberdeen was a wilderness, but the first railroad train arrived July 6, of that year,[247] and in June, 1882, it had a population of 500.[248] Blunt was first settled in the fall of 1882. In December of 1883 it boasted a popu-

[239]The decrease there was produced in part by the almost complete destruction of Deadwood by fire in 1883.
[240]Brennan, John: Conditions and Resources of Southern Dak., p. 3, (Sioux City, 1872).
[241]Hist. and Progress of Central Dak., p. 1, (Chicago, 1882).
[242]McClure: loc. cit., p. 87.
[243]McClure: loc. cit., p. 243.
[244]Andreas: loc. cit., p. 145.
[245]McClure: loc. cit., p. 243.
[246]Andreas: loc. cit., p. 136.
[247]Polk's Gazetteer for 1882, p. 902.
[248]Andreas: loc. cit., p. 136.

lation of nearly a thousand, occupying 300 well-made buildings. In May, June and July, 1883, real estate transactions amounted to $150,000 and business property advanced 300% in value.[249] Mitchell dates from May, 1879. It obtained a railroad in September, 1880, and a United States Land office in October. It was incorporated in 1881 and had a population of 1200 in 1882. With the building of the second railroad, it had a wonderful growth in 1882-83, during which time flour mills, feed mills, an elevator, foundry, machine shop, and brick yards were established.[250] Woonsocket was platted in September, 1883. Two months later it had 525 persons, and seven months later it had more than 800.[251] "The site of Redfield prior to July, 1882, was an unbroken wilderness."[252] In November of that year it was reported to have 1000 residents.[253] Brookings, first settled in 1879, but not recorded as a town by the census of 1880, had a population of 800 in 1882.[254]

In 1878 the largest place in the area now forming eastern South Dakota was Yankton, the capital. It had a population of 737 by the census of 1870 and perhaps but few more than a thousand people in 1878. Sioux Falls, the second center, was then a village of 600 or 700 people.[255] Vermilion was third in rank. So great was the influx after 1878 that by 1880 four places, Watertown, Canton, Elk Point, and Vermilion, had a population of more than 500 but less than 750 each, while two, Sioux Falls and Yankton, had 2164 and 3431 respectively. Sixteen other towns are recorded by the census of 1880, but Aberdeen, Brookings, Pierre, Redfield, Milbank, Webster, Sisseton, Chamberlain, and other towns of present prominence had not yet been founded, while Mitchell had a population of only 320, Huron of 164, and Madison of 96. By 1885 the places named above were significant towns, as they still are. When the boom began, few people foresaw which of the scores of towns platted were to become important cities, and which were to remain mere way-stations or county trading posts. Ambitious men of ability settled in about in equal numbers in each of many villages and each endeavored to make his town the chief one of the section. The rivalry between various towns therefore became very strong and resulted in many incidents that were ludicrous and many disappointments that were pathetic.[256] With few exceptions each town tried to become county seat. In several counties violent possession was taken of the county records.[257] A few examples of keen rivalry follow: In Sanborn county, Letcher contested with Forestburg (centrally located) for the seat. When Woonsocket secured two railroad lines and became the only town in the county so favored, the records appeared there mysteriously and Woonsocket succeeded in retaining them.[258] In Charles Mix County, there have been several contending towns, and Wheeler, an insignificant place not possessing a railroad, is the county seat. In Bon Homme County, Bon Homme, the oldest town, finally lost the seat of local government to Scotland, a railroad town.[759] In Turner, Swan Lake was for years the chief town and county seat, but it was not entered by a railroad and as a result slowly declined and finally lost the county seat. In Tripp county, Lamro, with a population of more than one thousand in 1910, the county seat, was on the direct line of a projected railroad, completed

[249]Ibid., p. 150.
[250]Ibid., p. 143.
[251]Ibid., p. 169.
[252]Polk's '82: loc. cit., p. 1081.
[253]The History and Progress of Central Dakota, p. 19 (Chicago, 1882.)
[254]Polk's '82: loc. cit., p. 926.
[255]It has a population of 593 in 1873, but did not increase much until a railroad arrvied in 1878 (King's Handbook of the United States, p. 793, New York, 1896.)
[256]Robinson, Doane: loc. cit., p. 157.
[257]Appleton's Annual Encylopedia for 1884, Dakota, (New York, 1885.)
[258]Andreas: loc. cit., p. 169.
[259]Ibid., p. 146.

to within a few miles. When the line was extended in 1911, a curve was made to avoid Lamro, and a railroad town named Winner was laid out little more than a mile away. Lamro was deserted, its buildings being moved to Winner, which became a town of 1500 almost immediately. There have been many other instances of railroad favoritism in Dakota, especially before the Board of Railroad Commissioners began its work in 1884.[260]

For the foregoing reasons, and others, there was great uncertainty about the future of towns during this boom period. This is illustrated by contemporaneous gazetteers. In one of them,[261] Huron, which in three or four years became, as it still is, one of the more important cities of the state, received only mention, two and a half lines being given to it. In the same volume thirty lines were given to a discussion of Jamesville in Yankton county, a town which soon disappeared. Scores of other towns which disappeared within a few years, received extended notice.

The boom times were brought to an end chiefly by crop failures. In 1886 "Dakota suffered in common with the rest of the country from business depression and from drought which injured the small grains, producing a shortage of at least a third in wheat and oats. The drought was local, some localities having splendid crops and others almost total failures of small grain."[262] A weather bureau estimate places the shortage of crops at 50%.[263] In 1887 there was a severe and widespread drought. In many counties little harvesting was done.[264] In 1888 droughts were local only, and the average crop was not much below reasonable expectations,[265] but "the terrible drought of 1889 produced widespread destitution."[266]

Other factors helped end the boom. The free land east of the Missouri River was nearly all taken by the summer of 1887. This region was fairly well supplied with railroads at that date, and few lines were built, with the result that towns which had looked for a railroad or for additional lines, began to lose hope. Financial conditions in general were less and less satisfactory, and loans were harder to secure. The difficulties became greater after each drought.

While the exodus from Dakota which followed the collapse of the boom was produced primarily by the drought, it was increased by disappointments in business and land speculation. Furthermore, thousands left who had come to the region chiefly to secure land while it could be obtained for little or nothing from the government, and without any firm intention of making it their permanent home After receiving title to their claims, many did not need even a moderate drought to induce them to leave.

### 5. The Admission of South Dakota to Statehood

An urgent demand for statehood resulted from the great influx of 1879-86, and after vexatious delays, South Dakota was admitted in 1889.

The movement for statehood began during the first boom (1869-74). A memorial to Congress calling for a division on the 46th parallel of the Territory and for the admission of the southern part as a state was passed unanimously by the Legislature Jan. 12, 1871.[267] A similar memorial was passed with but four dissenting votes on Dec. 31, 1872. This memorial again was passed with but one dissenting vote Dec. 19,

[260]See Annual Reports of this board, especially page 9 of the 1st.
[261]Polk's Gazetteer for 1881, p. 874. (Detroit, 1881.)
[262]Governor's Report to the Sec. of Interior for 1886.
[263]Finley: loc. cit., p. 28.
[264]Ibid., p. 28.
[265]Ibid., p. 29.
[266]Governor's Report for 1890.
[267]Hagerty, F. H.: The State of S Dak., p. 31, (Aberdeen, 1889).

1874, and unanimously on Jan. 24, 1877.[268] Between 1876 and 1878, the time of the gold-rush to the Black Hills, there were vigorous demands for the creation of a Territory of the Black Hills, to be called Black Hills, Lincoln, Eldorado, or by some other appropriate name.[269] A bill to this effect came before the senate in February, 1877.[270] In 1879 a protest against the admission of Dakota as one state was sent to Congress praying for the admission of three states, one to center about the Black Hills, was passed by the legislature.[272] A bill to this effect was reported favorably in each house of Congress, but passed neither.[273] In 1883, "After an unparalleled volume of immigration to southern Dakota, which is believed to have received fully 250,000 people in the two preceding years,"[274] another memorial praying for a division and admission was passed. The removal in 1882 of the territorial capital from Yankton to the more centrally located Bismark, intensified the desire of the southern part for statehood. A constitutional convention of 350 delegates assembled at Huron June 19, 1883, and another at Sioux Falls on September 4th of the same year. A constitution was adopted by a two-thirds majority on Nov. 3, 1883, but was ignored by Congress.[275] Jan. 19, 1885, a memorial was passed unanimously by the legislature praying for a division on either the 46th parallel or the seventh standard parallel, for the admission of two states. This memorial states that "The probable division has been considered at every territorial political convention held in the past thirteen years, and these conventions, in almost every instance without a dissenting vote, have invariably declared for division. Public institutions have been located[276] and built with a view toward division.[277] Additional reasons for dividing are set forth in this document, such as: "The union of the two sections into one state would be unnatural and would lead to endless difficulties. The division prayed for is wise. It will quiet strife, prevent difficulties and misunderstanding, and will promote the interests of both sections."[278] "During 1886 to 1889 there was much agitation for a separate state for the Black Hills by the people of the the Hills, but it was to no purpose."[279] The division of Dakota into North Dakota and South Dakota and their admission as states was made a national issue by the Republican party in 1888. This party prevailed in the election, and the bill was passed Feb. 14th, 1889. The people on October 1, readopted the constitution of 1885 and the two states were admitted Nov. 2, 1889.[280]

The boundaries of the state are discussed in Chapter I (p. 9.) At this point a few quotations concerning the causes for a division of the territory will be in order. "Division was inevitable. The great territory contained three one-sided centers of population, widely separated and differing in social interests, products and transportation facilities."[281] "There was at this period an inherent difference between

[268]Ibid., p. 31.
[269]Tallent, A. D.: The Black Hills, p. 360, (St. Louis, 1899).
[270]Ibid., p. 380.
[271]Hagerty: loc. cit, p. 31.
[272]Ibid., p. 231.
[273]Rosen, Peter: Pahasapa or the Black Hills, p. 396, (St. Louis, 1899).
[274]Hagerty: loc. cit., p. 31.
[275]Andreas, D. T.: Historical Atlas of Dak, p. 100, (Chicago, 1884).
[276]The location of the state institutions of both states is unfortunate; nearly all are situated near the eastern or southeastern boundary.
[277]"A memorial to the Congress of the United States from the Legislative Assembly of Dakota Territory praying for the division of Dakota and the admission of the southern portion as a state. Passed Jan. 19, 1885, Bismark," p. 6.
[278]Ibid., p. 8.
[279]Tallent: loc. cit., p. 383
[280]Robinson, Doane: A Brief Hist. of S. Dak., p. 171, (New York, 1905,.
[281]Hagerty, F. H.: The Terr. of Dak., p. 5, (Aberdeen, 1889)

the people of northern and southern Dakota. South Dakota was chiefly occupied by homesteaders who brought with them the conservative notions of the small farmer about public and private economy, morality and education. On the other hand, North Dakota was controlled chiefly by bonanza farmers, captains of industry, whose traditions were entirely at variance with those of the homesteaders of South Dakota"[282] (and later of western North Dakota).

Large holdings of land were secured much more readily and promptly by wealthy men in northern Dakota than in southern, as in the former there were large tracts of railroad lands given by the government to subsidize the building of the Northern Pacific Railroad. There were no such lands in southern Dakota. The fact that the nearly level Red River Valley occupied early by bonanza wheat farmers, has its southern end near the 46th parallel possibly was an influence, as was the fact that this parallel divides Dakota nearly equally. Aside from the seventh standard parallel four miles to the south, no other division line appears to have been suggested officially.

### 6. Dry Years and Their Effects

As noted in Chapter V (climate), local droughts are to be expected somewhere in South Dakota nearly every year, and widespread droughts are likely to occur at not infrequent intervals. Some of the influences of the severe droughts of 1864, 1874, 1886, 1887, and 1889 have been noted. The longest and most widespread drought in the history of the area commenced in 1889, and lasted in most sections until 1896 or 1897. Rainfall was deficient for a large part of South Dakota nearly every year of that period, and in several years there was an almost total failure of crops in many counties.[283] A discussion of the amount and distribution of the precipitation and the effects on yields occurs in Chapter V (p. 60.) The importance of droughts in bringing the Great Boom to a close and in producing an exodus of population also has been mentioned. The exodus continued for several years. It was increased by the panic of 1893 produced in part by widespread drought in the Great Plains and in the Prairie Plains during this and the two preceding years. Many counties of South Dakota, most of them west of the Dakota River, decreased greatly in population; and in 1897 many probably had less than half as many people as they had a decade before.

The exodus produced by the droughts was selective in character. The less patient and those readiest to start again elsewhere usually left soonest. The proportion of foreigners in South Dakota was increased conspicuously, while that of Americans born in certain states, especially New England and New York, decreased greatly. Many native Americans, being more or less familiar with other parts of the country and having friends and relatives in other regions, soon discovered greater opportunities elsewhere. As a class they probably were more likely than recent immigrants to have the funds with which to move. Others lacked the perseverance to await favorable seasons, or the patience to sow a second or a third crop when the preceding one or two had been failures. Most of them, being accustomed to some degree of prosperity, were unwilling to subsist on the meager diet and endure the other hardships imposed by dry years and partial crops. Most of the foreigners in Dakota had come from northern Europe or eastern Canada and many of them were accustomed to poverty and meager crops resulting from infertile soils, tiny fields, or adverse climate. Some of the immigrants found conditions in Dakota even during the

[282] Robinson, Doane: loc. cit., p. 172.
[283] Robinson, Doane: A Brief Hist. of S. Dak., p. 171, (New York, 1905)

worst half-decade an improvement over those they had left. Such as were inclined to leave Dakota were in most cases prevented by lack of information concerning other regions or for want of funds with which to move.

In view of the foregoing facts, the following statements are not surprising: "The population of southern Dakota is largely native Americans, mostly coming from New England, New York, Illinois, Indiana, Wisconsin, Iowa, Pennsylvania, and Ohio. There also are a number of Norwegians and Germans.[284] In 1872 it was estimated that in Minnehaha and Lincoln counties the population was about 50% Yankees, and that most of the rest were Scandinavians;[285] that in Union County "out of every seven, two are Anglo-American, two French-American, two Scandinavian and one Irish, there being only a dozen German families in the county."[286] "In Clay County about one-third are Anglo-American, one-third Scandinavians, one-fifth Irish, and one-sixth Germans and French-Americans."[287] "In Yankton County perhaps one-half are Anglo-Americans, one-fourth Scandinavians, and the rest Bohemians, Germans and Irish."[288] "In Bonhomme County one-half are Bohemians, two-fifths Anglo-Americans, and one-sixth Irish."[289] When it is recalled that the last and the first two counties mentioned above then had very small populations, it appears that the foreign element was not larger than 50%. During the Great Boom a flood of native Americans quite submerged, in many counties, the foreign element.[290] Codington County, credited with more than 6,000 people in 1884, was settled very largely by New Yorkers.[291] Beadle County, with a population of 10,000 in 1884, was settled chiefly from Illinois, Iowa, Indiana, Wisconsin.[292] Spink County was settled first by a colony from Boston, but soon many settlers came from Minnesota, Iowa, Illinois, Michigan, and Misconsin.[293]

At the census of 1885, 72% of the population of southern Dakota were native-born Americans.[294] Although this element was increased to 73.9% in 1890, and to 78% in 1900, the foreign element had increased relatively, as shown by the figures for the children of foreign-born parents. In 1890 these made 31.4% of the population, while in 1900 they made 38.9%. The total foreign element (including native children of foreign-born parents) was 57.5% in 1890, and 60.9% in 1900. Probably the ratios were more nearly 50% in 1887 (at the close of the Boom) and 75% in 1897, when a great influx of native Americans began.

The Boom affected not only the size and the temperamental and racial characteristics of the population, but also its distribution within the area and its occupations. Land values likewise were changed greatly.

Six counties in the southeastern part of the state in which it is claimed that there was in no year failure both of small grain and corn crops, decreased in population little if any, while other counties lost heavily. Much land which had been filed on west of the Missouri River, especially in Stanley, Lyman, and Fall River counties, was de-

[284]Batchelder, Sec.' The Hist. of Dak., p. 45, (Yankton, 1870).
[285]Brennan, John: Conditions and Resources of Southern Dak., p. 22, (Sioux City, 1872).
[286]Ibid., p 22.
[287]Ibid., p. 25.
[288]Ibid., p. 28.
[289]Ibid., p. 30.
[290]"It is from New York and Ohio that we have taken the models of our laws, while the basis of our local institutions and usages of government is essentially that of New England," (Smith and Young, Civil Government of S. D., p. 63, New York, 1904)
[291]Andreas: Historical Atlas of Dak., p. 158, (Chicago, 1884).
[292]Ibid., p. 145
[293]Ibid., pp. 140, 141.
[294]Hagerty, F. H: Dictionary of Dak., p. 10, (Aberdeen, 1889).

serted by farmers. Some of this land presently was used by stock rangers. In the eastern part of the state, especially on the western Coteau, areas relatively remote from railroads were deserted by farmers soonest and most completely, other things being equal. Many farms having relatively poor soils also were abandoned promptly.

Farming methods were changed. Varieties of plants better suited to the climate were grown, and more care was given to the preparation of the ground. The custom of burning the stubble and "discing in" seed which had been scattered broadcast was replaced generally by the practice of plowing or double-discing the land and planting by drill. The rotation and diversification of crops received greater attention. Mixed farming replaced "pure" or "straight" farming on many farms; livestock were introduced on most farms; and dairying became much more important than formerly. Other changes are noted in the section on agriculture (p. 115.)

Land values decreased greatly as a result of the years of drought. In 1870 unimproved land in the Missouri Valley was worth from $3 to $5 per acre if without trees; if heavily wooded, it was worth $15 to $40. Improved land without timber was worth $8 to $25 per acre.[295] In 1872 land near Vermilion, a railroad town, sold regularly at $15 to $30 per acre, while ten miles north land was sold for $3 to $10[296] The construction of the railroad from Sioux City to Yankton is said to have "doubled the value of all the land of southern Dakota."[297] In 1882 land near Sioux Falls was sold for $5 to $18 or more per acre; near Huron, $6 to $20; near Elk Point, $4 to $25 or more; and near Canton, $4 to $12.[298] During the height of the Boom, 1883 to 1885 inclusive, little or no land to which title could be given could be had for less than $10 per acre; most unimproved land was held at more than twice that, a price justified by the crops obtained. During the hard times of the early 1890's, when prices of crops were low and yields were small, land values fell to such an extent that $10 an acre was considered a very good price in most counties, and tens of thousands of farms could have been bought for less than half that. Indeed, much land was sold for taxes.

The droughts made it more difficult to secure water for household use; most shallow wells failed, and many of the farmers who were financially able undertook the drilling of deep wells. Irrigation also was much considered during that period. The feasibility of diverting waters from the Missouri River in North Dakota to irrigate the more nearly level parts of the Dakota Valley was much discussed. Topographical relations favored the plan, but the volume of water carried by the Missouri is so uncertain that it was abandoned. There was much talk of drilling many large artesian wells in order to irrigate with ground waters. The Federal Government called for a report on this subject[299] and drilled several wells, most of them in Indian reservations, but no widespread system of irrigation was adopted.

### 6. Wet Years and the Return of Good Times

Commencing about 1895, the rainfall increased, and, of much more importance to agriculture, a larger proportion of it came when needed by plants. Finally, in 1898, a series of "wet years" commenced, and fairly satisfactory conditions continued in most of the state until 1910. As a result, these were years of bountiful yields and of great

[295] Foster, J. S.: Outlines of Hist. of Dak., pp. 45, 54, 88, (Yankton, 1870).
[296] Brennan, John: Conditions and Resources of Southern Dak., p. 95.
[297] Ibid., p. 4.
[298] Polk's Gazetteer for 1882, loc cit., pp. 1069, 1021, 932.
[299] Culver, G. E.: The Practicability of Irrigating with Artesian Waters in the Dakotas, (Washington, 1893).

prosperity. Bank deposits in South Dakota increased 600% between 1900 and 1910.[309] Land values increased greatly. The aggregate value of all farm lands increased 377% between 1900 and 1910. The total increase between 1895 and 1910 was at least 500%. Many farms increased in value more than 1,000% in the fifteen years. The increase in population between 1895 and 1910 was 252,913, more than 76%. A large proportion of this increase was west of the Dakota Valley, and more than 50% was west of the Missouri Valley, in which area the increase in population between 1903 and 1910 was perhaps 400%. Twelve counties were organized in the latter region as a result of this influx, and nearly all the government land available was taken up. The eagerness of many people to secure some of these lands is reflected in the following statements: In 1904 a part of the Rosebud Indian Reservation was open to settlement; 106,000 persons applied for the right to homestead land, none of which was free, and most of which cost $2.50 or more an acre. In 1907 a small part of the Brule Reservation was opened, and 4,350 persons registered for some one of the 343 homesteads available. In 1909 most of the Cheyenne and Standing Rock Reservations were opened, and there were 80,142 entries for 10,000 homesteads.

### 7. Recent Years

The years 1910, 1911, and, in many sections, 1912 as well, were exceptionally dry, as dry as any three consecutive years in the early 1890's. In 1910 the average rainfall of the state was only two-thirds the normal amount, and although the total amount in 1911 was greater, a considerable share came in the autumn when it was a handicap, as it interfered with harvest. In 1913 fairly satisfactory crops were obtained in most regions, while in 1914 yields were good on the average. The weather conditions of these years are discussed further in Chapter V.

The effects of these dry years in the western part of the state were somewhat similar to those produced by the dry years which terminated and followed the Great Boom. There was a considerable exodus from this section, and land values fell in some cases to $5.00 an acre. Little land was abandoned, however. The farmers that remained acquired larger holdings, by lease or purchase, and by raising more livestock, practicing "dry farming," and cultivating alfalfa,, continued to utilize most of the land. In the eastern part of the state, the effects were far less pronounced. There most farmers practice mixed farming, pay much more attention to the selection of suitable varieties of plants, and employ methods of tillage better suited to local conditions. Many have artesian wells which afford a constant supply of water for their stock even in the dryest years. In each of these particulars, conditions there have improved greatly since 1887, and the occasional drought is far less disastrous than formerly. In the southeastern quarter of the state, land values have continued to rise, stimulated perhaps by the contrast between this section and areas less fortunate in respect to rainfall. Many farms in this quarter have sold recently for more than $175 per acre, and some for more than $200.00 per acre.

Conditions during recent years are treated in more detail in the first third of this chapter, under "Present Conditions."

## SUMMARY OF SETTLEMENT

Most of the settlement of this area took place during three boom periods, the second or "Great Dakota Boom" being the one during which the largest addition to the population was made. Between the periods of rapid settlement, the population increased slowly or not at

[309]Johnson, F. E.: S .Dak., A Republic of Friends, p. 63, (Pierre, 1911).

all. Each of the booms was due to railroad extension and a series of wet years; each was terminated by poor crops, due in most cases to droughts.

The first boom began in 1868, and developed rapidly in 1870. In the former year, Sioux City, Iowa, was reached by railroads, and in the latter year several lines approached and fifteen projected lines which were to serve Dakota were much talked of.[301] However, railroad building was stopped by the panic of 1873,[302] before southern Dakota had many miles of railroad, and the boom was terminated by the ravages of grasshoppers between 1873 and 1875,[303] the crop of 1874 being nearly destroyed by them. Thousands of persons were reduced to the verge of starvation.[304]

The Great Dakota Boom was inaugurated in 1879, after two years of good crops, by renewed activity in railroad building. The presence of a large mining population[305] in the Black Hills was one incentive for railroad extension in that direction, and the appropriation of nearly all the land in Iowa was another. During this boom nearly 2,500 miles of railroad were built in the area now included in eastern South Dakota,[306] and a flood of settlers occupied most of the eastern half of the state, and parts of the western half. The Sioux Reservation delayed until 1889 the occupation of a large section west of the Missouri River. The population of southern Dakota increased from perhaps 60,000 in 1878[307] to more than 350,000 in 1886.[308] When all the better land available had been filed on, the further influx of settlers was stopped by severe droughts in 1886[309] and 1887.[310] The widespread droughts of 1889[311] and of the early 1890's drove thousands from this area, as from other sections of the Great Plains and nearly depopulated certain counties, especially those west of the longitude of the Dakota River.

The third boom commenced in the eastern part of the state about 1898, as a result of fairly good crops for two or three years. During the decade 1900-1910 farm land values increased 377%,[312] and the population of the state increased 45%.[313] All the more desirable land of the section east of the Missouri was again occupied, and a strong demand developed for railroad extension and for the opening of the Indian reservations west of the Missouri River. This was due in part to the fact that settlers had reported good harvests for several years

[301]Batchelder: Sketch of Hist. and Resources of Dak. Terr., p. 43, (Yankton, 1870)

[302]Polk's Gazetteer of Minn. and Dak. for 1881, p. 782. (Detroit, 1881).

[303]Trumbo: Reminiscences, S. D. Dept. of Hist. Coll., Vol. V, p. 89, (Pierre, 1910).

[304]Andreas: Hist. Atlas of Dak, p. 164, (Chicago, 1884).

[305]16,487 by the census of 1880.

[306]More than 2000 miles were built in Dak. Terr. by 1883 (Kerr: President's Annual Address, S. D. Hist. Soc., S. D. Dept. of Hist. Coll., Vol V, p. 81, 1910), and in the fiscal years ending June 30, 1885, 1886 and 1887, 145 miles, 679 miles, and 716 miles (Annual Reports of R. R. Commissioners, 1-111). Southern Dak had less than 100 miles in 1878, and more than 2600 miles a decade later.

[307]The population was 11,925 according to the census of 1870. It had doubled by late in 1872 (Brennan, John: Conditions and Resources of Southern Dak., p. 39, 1872). The increase 1873-78 was slow, while from 1878 to 1880, when 98,711 are recorded, the increase was rapid.

[308]There were 263,411 by the census of 1885 (June) and in addition to an unknown increase for the balance of that year there was an estimated increase of 85,000 for 1886, (Commissioner of Immigration, quoted in Report of Governor in 1886).

[309]Governor's Report to the Secretary of the Interior for 1886.

[310]Finley, J. P.: Certain Climatic Features of the Two Dakotas, p. 28, (Washington, 1893)

[311]Finley: loc. cit., p. 28.

[312]Bureau of Census: Supplement for S. Dak., p. 615, (Washington, 1913).

[313]Ibid., p. 568.

even in the drier parts of the state. Finally the Missouri River was bridged at Pierre and Chamberlain in 1907, and at Mobridge in 1909. Between 1906 and 1910, inclusive, several hundred miles of line were built west of that river, and by 1911 nearly all the government land of much agricultural value, and open to entry, had been filed on.

During the decade 1900-1910 the total population of the area west of the Missouri River, Lawrence County in the Black Hills excepted, increased nearly 440%, from 27,343 to 115,973.[314] Most of this increase occurred in the last third of the decade.

Several dry years, of which 1910 was the first and the most severe, have caused many homesteaders to leave soon after receiving patents for their claims, decreasing greatly the population of many western counties.

Geographic conditions, especially climate, have been powerful influences in this area. The native flora, funa, and the settlement and development of the area clearly reflect these conditions; and the activities of the people are chiefly in response to geographic conditions. From a geographic viewpoint, the area seems destined to remain predominantly agricultural, and much of the western half, at least, of the type in which stock raising is prominent.

[314]Thirteenth Census: loc. cit., pp. 596-609.

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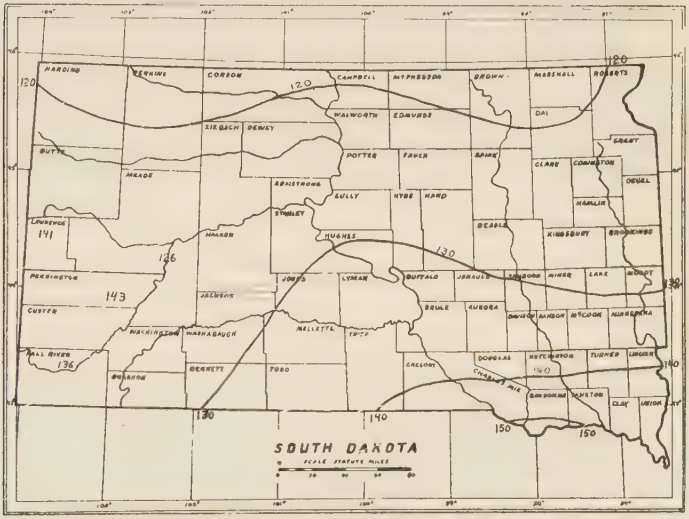


Fig. 38. Average Length of the Crop Growing Season, in Days.

Fig. 39. The Largest Lignite Mine in the State, Near Strool, Perkins Co.

Fig. 40. Range Horses at Water Hole, Fall River Co.

Fig. 41. The City of Pierre from Across the Missouri River.

Fig. 42. A View of Rapid City showing the foothills in which the Dakota sandstone, of artesian well significance, outcrops.

Fig. 43. The Missouri River Near Vermilion, S. D.

Fig. 44. Lead, S. D., the largest city of the Black Hills and the site of the Homestake Mine.

Fig. 45 Pierre, Showing the Capitol in the Distance.

Fig. 46. Aberdeen, looking north from the Citizens Bank Building.

Fig. 47. A farm home near Aberdeen, and a part of an oat field which yielded 70 bushels per acre.—Courtesy C. M. & St. P. R. R. Co.

Fig. 48. A wheat field near McIntosh, in the northwestern quarter of the state.—Courtesy C. M. & St. P. R. R. Co.

Fig. 49. A general view in eastern South Dakota (Bath.)—Courtesy C. M. & St. P. R. R. Co.

Fig. 50. A wheat field near Webster in the northeastern quarter of the state. Courtesy C. M. & St. P. R. R. Co.

Fig. 51. A typical mixed farming home in North Central South Dakota.—Photo by J. W. Parmley, Ipswich, S. D.

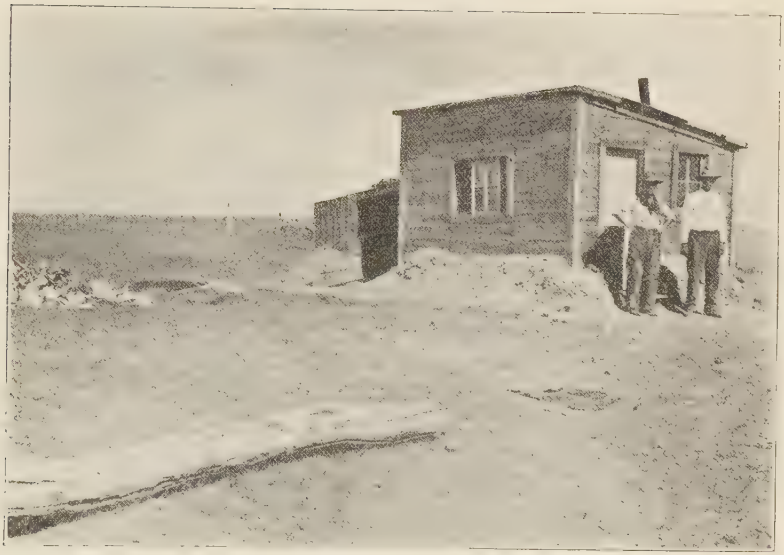

Fig. 52. Claim Shanty.

South Dakota State Geological and Natural History Survey

FREEMAN WARD, *State Geologist*

BULLETIN 8

# *The Geography of South Dakota*

BY

S. S. VISHER

Report of the State Geologist
1916—1918

UNIVERSITY OF SOUTH DAKOTA
VERMILION JULY, 1918

University of South Dakota, Department of Geology, State Geological Survey, Vermillion, S. D.

June 21, 1918.

Regents of Education,

Pierre, S. D.

Dear Sirs:

I have the honor herewith to submit my report to be published as bulletin number eight of the State Geological and Natural History Survey.

It consists of two parts,—one is "The Report of the State Geologist for 1916-1918;" the other is the important and well prepared technical paper "The Geography of South Dakota" by S. S. Visher.

Respectfully,

FREEMAN WARD,

State Geologist.

## BIENNIAL REPORT OF THE STATE GEOLOGIST 1916-1918

### INTRODUCTORY.

The last report carried the Survey up to September 1st, 1916. The present report covers the activities of the Survey from that date to July 1, 1918. The statistics, however, reach only to June 1, 1918, those for the month of June will be included in the succeeding report.

The permanent staff of the Survey remains the same,—Freeman Ward as State Geologist, W. H. Over as Naturalist. R. T. VanTuyl acted as field assistant during July and August, 1917.

The work of the Survey will be considered under the following headings and in the order given,—Field Work, Service Bureau, Museum, Publications, Accessions, Relation of the Survey to the War, Miscellaneous Activities, Needs of the Survey.

### FIELD FORK.

1916,—The work of the field season of this year was discussed in the preceding report.

1917,—The State Geologist, starting out about the middle of June, spent a short time in Rapid City in conference with Prof. C. C. O'Harra on the War Minerals situation. He then went immediately to Mobridge to take up the main work of the season. Soon after the first of July he was joined by Mr. Over and Mr. VanTuyl.

It was planned to survey the Missouri River and the territory immediately adjoining from the north part of the state down to Pierre. In order to make the trip possible a boat was built large enough for the party, equipment and supplies. In addition a light skiff was provided.

Since the territory to be surveyed was in the gas belt of the state the State Geologist hoped that detailed examination might bring to light some positive information regarding oil. But only negative results were obtained throughout the entire course of the trip. Despite this, a considerable amount of valuable information was secured concerning the various geological conditions of the region.

Mr. Over's work was twofold. He made a study of the plant and animal life to supplement the rather meager data we had of that area. In addition, he made a large number of archeological discoveries. His work of previous seasons had lead him to expect a series of ancient Arikara village sites at various points along the river. This proved to be the case. Tools, weapons, implements, of various sorts, ornaments and skeletal material were found in considerable quantity.

While camped some miles below Mobridge word was received that oil was reported to have been found in wells at Mahto and McIntosh, Corson County. Several of the business men of Mobridge, headed by Mr. B. S. Hill, were enough interested in the affair to pay the expenses of the State Geologist for a special trip to these localities. Unfortunately the conditions did not turn out to be as favorable as they seemed to promise at first.

The status of the oil problem of the state is given in outline in Circular Number 1.

Additional Trips,—Several short trips were taken outside of the regular field season.

About the middle of December, 1916, a mastodon skeleton was reported found near Sioux Falls. Mr. Over went there to investigate. The bones proved to be only fragments of chalk rock. But since mastodon

bones have been found in the state all reports need to be looked up whether they turn out to be favorable or not.

During the latter part of December, 1916, the State Geologist attended meetings of the Association of State Geologists in New York City and Albany, N. Y. At that time he presented a paper on the "Geological History of South Dakota."

In September, 1917, an old Indian grave was discovered near Centerville. Mr. Over made a trip there, recovered additional material, and. through the courtesy of Mr. A. A. Norgren, was able to have the whole find returned to the Museum.

In November, 1917, Mr. Over investigated several Indian mounds near Madison and secured some good material.

In April, 1918, a conference on War Minerals was held by the Association of State Geologists with the U. S. Geological Survey and the U. S. Bureau of Mines at Washington, D. C. The State Geologist attended this meeting.

Occasional short trips have been taken in the vicinity of Vermillion from time to time.

**SERVICE BUREAU.**

This important branch of the Survey work seems to be growing. A continually increasing number of inquiries has come in both from citizens of the state and from persons and companies in other parts of the country. A great variety of information is sought. Specimens of many kinds are sent in for identification. Some analytical work has been done through the Department of Chemistry of the University.

Approximately 375 inquiries have been received and answered by mail. Personal talks with and advice from some one or the other of the Survey staff are of almost daily occurrence.

The completeness of the answers given is determined by the amount of information on hand. Much of this can be gained only by field work. The more thoroughly the state is explored and mapped the better can the Survey serve the people.

The Survey is finding that it can serve the producers of the state by centralizing the statistical information from their mines, mills and prospects. The producers are finding that the Survey, because of the centralization of data therein, is able to save them considerable clerical work and annoyance. This is one of the newer developments of the Service Bureau which promises to expand to much greater usefulness.

The State Mine Inspector is cooperating in this matter also.

**MUSEUM.**

While the State Geologist is technically the Curator of the Museum yet the actual museum work—arranging, cataloging, preparation of exhibits, etc., etc.,—has been in the hands of Mr. Over who has been extremely successful in all phases of the work.

The Museum is becoming an increasingly important factor in the educational achievements of the state. The collections of exhibit material are increasing. The specimens and other data are so classified that specific information along many lines is quickly available. That use is being made of the Museum is attested by the fact that there were approximately 5000 visitors during the period.

The total number of specimens acquired during the above period was approximately 2615. Most of these have been classified, catalogued and arranged for exhibition.

Those deserving of special mention are the fine elk head donated by Mr. Bert S. Hill, Mobridge, S. D.; the mounted mammals and birds loaned

by Mr. John Berens, Selby, S. D., and known as the "Berens Collection." This comprises among other things, a buffalo, antelope and four deer. And of unusual interest is the large collection of Indian skeletons and artifacts collected by the State Survey along the Missouri River during July and August, 1917. This material is valuable not only in rounding out our Arikara and Mandan Indian collections, but also has aided in deciding, conclusively, doubtful questions pertaining to early Indian history in South Dakota.

Below will be found a list of accessions. Except where otherwise indicated the specimens are donations.

Hawk, Albert Omdahl, Burbank, S. D.
Snake, Hog-nosed Adder, A. G. Warner, Clear Lake, S. D.
Sioux Indian Skeleton with Flint Lock Gun and Necklace, A. A. Norgren, Centerville, S. D.
LeSeuers Terrapin, George Lumley, Pierre, S. D.
Collection of Plants, Prof. Walter Parish, Gary, S. D
Avocet, Claude Crew, Interior, S. D.
Old Mauser Rifle and Indian Arrow, Geo. F. Bower, Vermillion, S. D.
10 Hematite Specimens, (Archaeology) Prof. R. W. Jones, U. S. D.
2 Cherry Stone Crushers (Sioux) Robt. Lindley, Bonesteel, S. D.
5 Box Terrapins, Wm. Palmier, Imlay, S. D.
48 Bird Skins, F. A. Patton, Artesian, S. D.
102 Mounted Mammals and Birds, John Berens, Selby, S. D. Loaned.
Collection Sea Moss, Prof. A. L. Haines, U. S. D.
43 Mounted Birds and one Mounted Skunk, John C. Green, Sioux Falls, S. D.
6 Mounted Birds and one Weasel Mounted, O. C. Stanghar, Sioux Falls, S. D.
3 Indian Skeletons, Beads and Stone Hammer, W. N. Gilbert, Madison Pass, S. D.
Snake, Hog-nosed Adder, J. C. Dawson, Vermillion, S. D.
Old Lincoln Campaign Chart, Mrs. C. A. Wilson, Vermillion, S. D.
Tarantula, Harlan Richardson, Vermillion, S. D.
Spider, E. Puhr, Highmore, S. D.
Old Tin Lantern, C. A. Wilson, Vermillion, S. D.
Shrew, Arthur A. Hale, Bison, S. D.
Marine Shells, Walter Willey, U. S. D.
Marine Shells, Miss Jesse Pangburn, Faulkton, S. D.
Barnacles, V. E. Eastman, Sioux Falls, S. D.
Skull, Clay County Court House Yard, Chas. Sunderling, Vermillion, S. D.
Spinning Wheel and Reel, Loaned, Dr. Freeman Ward, U. S. D.
6 Bird Skins, E. C. Eckert, Elk Point, S. D.
Fragments Old Survey Stake, Lake County, Porter Lowery, U. S. D.
Salamander, Dr. A. N. Cook, U. S. D.
Snake, Hog-nosed Adder, C. J. Stringham, Sioux Falls, S. D.
Snake, Red-bellied Snake, C. J. Stringham, Sioux Falls, S. D.
Bull Snake, E. M. Hall, Pierre, S. D.
Snake, Hog-nosed Adder, W. J. Chaussee, Vermilion, S. D.
Lizzard, Red-headed, V. A. Luttio.
Models of Road Beds (3) Dept. Civil Engineering, U. S. D.
Indian Flint Knife and Fragments of Pottery, F. E. Ratcliff, Vermillion, S. D.
Plant, Araucaria, Chris. Hansen, Vermillion, S. D.
Ring-necked Pheasant, Roy Davis, Vermillion, S. D.
Collection Grasses, A. E. Noyes, Redig, S. D.

Golden Eagle, A. E. Noyes, Redig, S. D.
Bird Skin, A. E. Noyes, Redig, S. D.
Squirrel Nest, Frank Bardwell and M. Minich, U. S. D.
Old Kentucky Rifle, Loaned, Prof. M. W. Davidson, U. S. D.
Old Revolver, Millard Purdue, Vermillion, S. D.
Colts Revolver and Collection Sioux Indian Relics, Loan, Dr. Freeman Ward, U. S. D.
Nest of Baltimore Oriole, E. D. Cowles, Vermillion, S. D.
Specimen Gypsum, Prof. A. L. Haines, U. S. D.
White Muskrat, Donald Harris and Lyle Swainson, Highmore, S. D.
Porcupine Skin and Buffalo Bones, E. A. Sheldon, Vermillion, S. D.
Indian Stone Hammer, R. E. Brown, Academy, S. D.
Indian Stone Hammer, Porter Lowery, U. S. D.
Indian Stone Hammer, H. L. Ferry, Vermillion, S. D.
Indian Stone Hammer, Rev. P. J. Reinethsen, Elk Point, S. D.
Young Muskrat, Dr. W. F. Jones, U. S. D.
Indian Stone Tomahawk, Stone Hammer, Mortar, Buffalo Head, 2 Clay Concretions, J. Martin Larson, Elk Point, S. D.
Moth, **Polyphemus**, Miss Villy Cleland, Vermillion, S. D.
"Kissing Bug," **Redwidae**, Mrs. Smith, Ft. Bennett, S. D.
Goshawk Roy Jones, Vermillion, S. D.
Goshawk, Roy Jones, Vermillion, S. D.
Abnormal Pig, 3 Snakes, Buffalo Head, C. B. Gilbertson, Vermillion, S. D.
Scorpion, Dick Willis, Andover, S. D.
Collection Minerals, Wood Carving, Buffalo Horns, Fossils and Shells, Mrs. T. M. Goddard, Vermillion, S. D.
Wood Carving by Ants in Norway, E. Ostland, Vermillion, S. D.
2 Copper Coins, Waldo Graves, Vermillion, S. D.
Dakota Sioux English Dictionary, E. F. Canaday, U. S. D.
Cannon Ball, W. B. Smith, Vermillion, S. D.
Cannon Ball, Cliff Hallas, Vermillion, S. D.
Old Grain Cradle, Atty. A. B. Gunderson, Vermillion, S. D.
Short-eared Owl, Kermit Davis, Vermillion, S. D.
American Horned Owl, J. T. Christenson, Lake Preston, S. D.
Snowy Owl, Andrew Boline, Centerville, S. D.
Snowy Owl, Ole Dahl, Ideal, S. D.
Snowy Owl, Harold Rice, Flandreau, S. D.
Snowy Owl, Jerry Smit, Platte, S. D.
Snowy Owl Alive, W. B. Smith, Mansfield, S. D.
Pair of Black Ducks and Least Bittern, H. G. Taylor, Vermilion, S. D.
Indian Baskets and Beaded Work, Loaned, W. Gray Tisdale, Sioux Falls, S. D.
3 Indian Stone Hammers, Lars Larson, Elk Point, S. D.
Old War Photo of Gen. Grant and Brig.-general J. McArthur, and others, H. L. Ferry.
Elk Head Mounted, Bert S. Hill, Mobridge, S. D.
American Horned Owl, Roy Davis, Vermillion, S. D.
Black Rat and Red Bird, Mr. Spatz, Meckling, S. D.
Chinese Coins, E. O. Sheldon, Vermillion, S. D.
2 Indian Stone Hammers, C. B. Rosa, Forest City, S. D.
Indian Beaded Vest and 2 Beaded Bags, Dr. B. F. Lockwood, Yankton, S. D.
Bayonet, Battlefield of Bull Run, Loaned, Prof. W. M. Davidson, U. S. D.
Mounted Deer Head, Deer Antlers and Indian Snow Shoes, changed from loan to donation by R. A. Morgan, Vermillion, S. D.
Indian Stone Hammer, Mrs. Alice L. Overholser, Glenham, S. D.
Indian Stone Hammer, 10 arrow points, R. H. Peterson, Mobridge, S. D.

Tarantula, J. H. Hartson, Vermillion, S. D.
Moth, Walter Harrington, Vermillion, S. D.
Golden Eagle, Am. Horned Owl, Loan, Vincent Conway, Westfield, Iowa.
Crows Nest and Eggs, R. T. Van Tuyl, U. S. D.
Polished Agate and 20 old Coins, Loan, Mrs. T. B. Thompson, Vermillion, S. D.
Flax Fiber and old Bread Basket, President Slagle, U. S. D.
Ox Bow, A. T. Kayser, Parkston, S. D.
Coated Well Pipe Point, M. B. West, Vermillion, S. D.
Plants and Sea Moss, Miss Mary Henderson, Calif.
Indian Photographs, Arrow, Minerals, Cane and Indian Ores, Mrs. W. W. Allen, Vermillion, S. D.
Irish Shillalah, Loaned, D. M. Eastman, Sioux Falls, S. D.
Weasel, Edwin Harrington, Vermillion, S. D.
Snow Goose, C. W. Over, Vermillion, S. D.
Whitefronted Goose, C. J. Stringham, Sioux Falls, S. D.
Copper Amulet, Worn by a Sioux Indian, James Hughes, Mobridge, S. D.
White Mouse, Adolph Iverson, Vermillion, S. D.
Collection of Algae, Dept. of Biology, U. S. D.
Nest of Chimney Swift, Mortimer Herzberg, Jr., Vermillion, S. D.
Hand-made Tools from the Philippine Islands, F. Ratcliff, Vermillion, S. D.
Fossil Aggregation, A. N. Williams, Akron, Iowa.
2 Sharks Eggs, Mrs. F. A. Brink, Pensacola, Fla.
Abnormal Pig, Guy Chamberlain, Vermillion, S. D.
2 Porcupines, Loaned, Geo. Butterfield, Pierre, S. D.
Collection of Carboniferous Fossils, changed from a loan to a donation by Dr. C. S. Thoms, U. S. D.

Specimens added by the State Geological and Natural History Survey are as follows:

22 Plants, 15 Bird Skins, 12 Snakes, 2 Mice, 4 Amphibia, 40 Arikara Indian Skeletons and 30 extra Skulls, 2000 Flint, Stone, Bone and Shell Indian Implements and Ornaments, 3 Omaha (?) Indian Skeletons and Beads from a Mound at Madison Pass and 4 Omaha (?) Indian Skeletons from a Mound near Brule Creek, Union County.

The following have been mounted for the Museum:

Buffalo Skeleton, 2 Golden Eagles, Lesser Snow Goose, American Horned Owl, Rabbit, Avocet, Least Bittern, Pair of Black Ducks, Pheasant, Nuthatch, Woodpecker, Brown Creeper, Muskrat, 7 Turtles, Weasel, Gar Fish, Sturgeon.

Added to the Museum by exchange:

5 Snakes and 3 Turtles.

An effort has been made to keep for exhibition purposes as many live animals as possible, but on account of no funds to purchase specimens nor to build suitable pens and buildings but little can be done. The following are on hand:

1 Coyote, 2 Porcupines, 1 Alligator, 1 Snowy Owl, 2 River Turtles and 3 Land Terrapins, and 5 Snakes.

One 2nd hand show case and one new base with 30 large drawers have been added during the period.

3 Arikara Indian Skeletons and 10 Skulls have been presented, and 24 Skulls loaned to the United States National Museum for investigation.

A number of Books and Bulletins have been loaned to individuals over the State who have been interested in subjects concerning Natural History.

The limitations and needs of the Museum will be discussed in a later paragraph.

**PUBLICATIONS.**

A new series of publications—Circulars—has been started by the Survey. The reasons for this step are as follows:

Often during the progress of the work enough information is at hand to be of value to those interested but not enough for a complete treatise. A part of a county may be finished, perhaps, and publication waiting on the complete investigation of the whole county. A problem under investigation may take several years to finish, yet certain phases of the investigation may yield results sufficiently complete to be of value by themselves. There may be a demand for statistical matter, or lists of references, or current information, etc., which would hardly do for a formal bulletin. Such partial reports, summary reports, reports of progress, or lists, etc., are to be handled in the Circulars. The Bulletin is to be reserved for the more detailed and formal treatment of problems whose investigation is complete or practically so. It is planned to publish the Circulars frequently and the Bulletins at longer intervals. With this arrangement much information will reach the public with a minimum of delay.

So far three Circulars have been issued, as follows:

No. 1—Oil in South Dakota. By Freeman Ward, Dec., 1917.

No. 2—South Dakota Fossils, by Freeman Ward, Mch., 1918.

No. 3—Protect the Birds and Help Win the War, by W. H. Over, June, 1918.

The manuscript on "The Geography of South Dakota" by S. S. Visher, which has been on hand so long, is herewith attached for publication as part of this bulletin.

A new geological map of South Dakota on a scale of twelve miles to the inch has been ready in manuscript for a year and a half awaiting publication.

A new base map of South Dakota on a scale of six miles to the inch has just been completed and is ready for publication. This map shows the county boundaries, drainage, railroads, county seats and many other towns, township and range divisions. It also shows the larger relief features by means of contour lines with a 500 foot interval.

The manuscripts for a bulletin on Birds is nearing completion, will undoubtedly be ready for publication early in the fall.

**ACCESSIONS.**

In addition to the material listed under the Museum, about 65 purely geological specimens—rocks, minerals, fossils, etc.,—have been collected by the Survey.

Many publications—Federal, State, Foreign—are received constantly. They are not kept separate from those received by the Geological Department of the University but are included in the departmental library.

**RELATION OF THE SURVEY TO THE WAR.**

The raw materials of war, and without which our war program would have to stop, are the natural mineral resources of the country. They are commonly designated as "War Minerals." They have always been in demand even in times of peace. Much has usually been imported by this country. Now that we are at war overseas traffic is difficult and uncertain. Moreover, the Shipping Board is withdrawing ships from the trade in order to hasten the transportation of men, food, munitions, etc. As a result the importations have been much curtailed, they may be cut off entirely. And the demand for these minerals is much greater than in peace times. All of which means that the domestic supply will have to be very much increased and that with a minimum of delay.

All the Federal Surveys and Bureaus and all the State Surveys are actively at work trying not only to speed up and increase the production from known deposits but also to discover new deposits.

Early in April there was a conference at Washington, of the State Geologists with the U. S. Geological Survey and the U. S. Bureau of Mines. The War Minerals situation was gone over thoroughly at that time and further plans drawn up.

It is regrettable to have to record that South Dakota, although the Survey has been in existence 25 years, has done so little to determine the kind and extent of its mineral resources that it is able to bring but a small amount of aid to our country at this time. We should have taken a complete inventory of our natural resources long before this. The fault has always rested with those in authority over the funds necessary for this extensive work. Each State Geologist has repeatedly urged the dire necessity for funds sufficient to maintain an adequate force of experts in active and continuous service. Neither regents nor legislators have had vision enough to see the connection between a geological survey and the needs of civilization. Now our country is facing a crisis in raw materials,—mineral resources—and South Dakota can help but little. This is because she does not know exactly what her resources are, for she has never maintained a Survey sufficiently well armed to attack the problem as it should be.

Last season the State Geologist spent what time he could (he has to teach nine months of the year) in looking up that valuable resource, oil. This season he will be out again. There are no funds for employing additional experts to hasten the work.

Another war service of the Survey has been in the matter of birds. Protection of the birds means saving of crops and so increase our food supply. The Survey is urging this matter in Circular No. 3.

The State Geologist has lectured twice on "The War Services of a Geologist."

**MISCELLANEOUS ACTIVITIES.**

The clays collected in the Sioux Falls region were tested as far as our facilities allowed. Because of very limited equipment they had to be sent off for the most important tests. For this purpose they were sent to Prof. H. Ries of Cornell University who is one of the leading clay engineers of the country.

There came to the attention of the State Geologist a machine, "Barnes' Electric Water Purifier," which claimed to be a water softener and purifier. The matter of softening hard water is a serious problem in this state. So a machine was purchased and experiments run to test out its value in this connection. It did not perceptibly soften the water and was demonstrated to be very largely a fake. The agent handling the machine was notified of its limitations and seemed glad to learn the truth concerning the device. The chemical analyses involved in the tests were made in the laboratory of the State Food and Drug Department with the generous permission of the Commissioner, Mr. Guy G. Frary.

At the suggestion of Mr. Over all those in the state interested in archeology were invited to attend a meeting held at Vermillion in the interests of that subject. A good attendance was realized and a number of papers were presented, two of them discussing South Dakota conditions,—"Pre-Historic Man in South Dakota," by W. H. Over. The State Geologist discussed the same subject from a geological standpoint.

All the work so far reported, including preparation of manuscript for Circulars, papers, etc., and work on maps, has to be sandwiched in with the regular university duties during the school year.

Mr. Over has given three lectures,—"Birds," Early Races of S. Dak.," "The State Survey and Museum."

**NEEDS OF THE SURVEY.**

As suggested under the topic "Relation of the Survey to the War," the Survey can do the best work and get results quickly only by maintaining an adequate staff of experts. This state is too large for one man to cover, especially when he can be in the field but three months of the year. Nor can one man be an expert in all lines of geology.

If experts are employed they must have suitable equipment,—laboratory, instrumental, clerical, etc.,—in order to be most efficient. One of the big aids to rapid and accurate field work is a topographic map. Such maps should be made with all possible dispatch so that the field work does not lag. There are many other uses for topographic maps than that for geological work (see Bull. 7, pp. 11, 12.)

Even with the present staff of the Survey—Geologist and Naturalist—the results could be increased at least threefold if there was sufficient money for transportation and unskilled labor and other like aids.

For instance,—Season before last the State Geologist did all his work on foot. A large share of his time was spent in getting to and from the work. An auto continually at hand would have enabled him to cover at least three times as much territory.

Again,—Last season if we had had a house boat with power instead of having to row, we would have covered at least three times as much territory with less exhaustion.

Furthermore, unskilled labor can move and set up camp, rustle wood and water, cook, dig holes, etc., etc., as well as skilled labor. Moreover, if an expert has to use part of his energy and time on manual labor and housekeeping, he has just that much less to apply to geology or natural history.

One indication of the need for complete and extensive information concerning our resources is shown by the fact that several business interests, with capital amounting to several hundred thousand dollars and desiring to build up industries around our resources, failed to locate in the state because the information was not sufficiently detailed to interest them.

Another most important need is the taking care of what we have and making it more useful. I refer to the Museum. The Museum is housed in a part of Science Hall. This is a most flimsy building. It is in no ways fireproof, it is scarcely weatherproof. A large portion of the collections now reposing in the Museum could never be replaced if once lost. There are historical and archeological materials the only things of their kind in existence. Our Arkara material, which the Survey has collected through the untiring efforts of Mr. Over, is unique, there is nothing to equal it anywhere. The State Geologist within the last year visited the Field Museum in Chicago, the American Museum in New York City, and the National Museum in Washington. He finds after careful inquiry that our Museum has at least five times as much Arikara material as those three famous museums together. It is undoubtedly true that we have the best collection of such material in the world. It is the height of indiscretion to give such fine material so little protection. Moreover it shows a lack of business sense. We have other excellent specimens. We have loan collections for which we are responsible. I cannot too strongly emphasize the need for a modern fireproof structure for our Museum.

The place we have for display is far too small. Such material as is now on exhibition would require twice the floor space to show it properly. In addition, a large collection of botanical specimens that have been acquired through exchange with other State Universities, two collections of fossils, and several hundred Indian implements and relics are all stored in boxes and drawers for lack of room to display. Display

cases and floor space is needed for collections illustrating the products of South Dakota.

The Museum has reached that stage of growth where the Mammals, Birds and Ethnological material should be displayed by the effective group system, not only to keep pace with other Museums but also to satisfy the demands of the public that use the Museum for educational purposes.

New and better cases are needed.

At least $500.00 should be available each year to purchase rare specimens, to fill out incomplete collections, and to send competent collectors after specimens, either in or out of the state, that are becoming rare and more difficult to obtain year by year. An equal amount should be spent annually to build up the live animal exhibit.

$50.00 should be at the disposal of the Museum each year to purchase much needed books pertaining to Natural History, and especially Bulletins, Reports, and Proceedings of scientific organizations of the United States that can be procured only by purchase. Reports and published proceedings that are particularly necessary are those of the Philadelphia Academy of Science and the Carnegie Institute, as well as U. S. Biological Reports that are out of print.

Funds are also needed for publication. The maps and bird bulletin prepared in response to a general call for them, are cases in point.

Collections of South Dakota minerals, rocks, plants, animals are desired in the high schools and other educational institutions of the state. The Survey can get these out when funds for this purpose are available.

In view of the pressing needs of the Survey and the great opportunity it has to further the interests of the State and also aid the country in this time of war, it is hoped that a very generous appropriation will be urged.